Erosion

And its Control in Oklahoma Territory

MISCELLANEOUS
PUBLICATION No.301
U.S. DEPARTMENT
OF AGRICULTURE

EROSION AND ITS CONTROL IN OKLAHOMA TERRITORY

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FOREWORD

The dust storms that have occurred on the Great Plains since 1934 have been of unprecedented intensity and extent. Even the cities of the eastern seaboard have felt the effects of the blowing dust. The sudden recognition of the menace of such storms to our agricultural lands has brought forth a multitude of comment in magazines and newspapers throughout the country. The phenomenon, itself, is not new but is the cumulative result of years of exploitation of the land, intensified by an unusually long and severe drought. To the farmers of the Plains, wind erosion has been a serious problem for 50 years. As the farming area increased, larger areas were exposed to the hazard of wind erosion during each of the successive periods of drought. Water erosion, equally serious, challenged the farmers during the heavy rains of spring and early summer. Since its effects were manifested only locally for a time, its broader significance escaped attention. Both types of erosion problems were until recently subordinated to the more immediate economic problem of conserving moisture for the production of crops in the semiarid Great Plains.

In a recent publication, Hall (*46*)[2] has shown that Virginia farmers felt the effects of erosion as soon as the land was cultivated. For over a century and a half the more progressive farmers have been trying to combat the growing evil in this, one of the oldest agricultural areas in the country. They have failed because there has been no general recognition of the evil nor a coordinated attack upon it. This same situation was repeated in Oklahoma Territory, one of the last agricultural areas in the country to be settled. Here also erosion was

[1] This publication was prepared under the direction of Lois Olson, in charge Erosion History Unit.

[2] Italic numbers in parentheses refer to Literature Cited, p. 45.

Issued March 1938

experienced as soon as cultivation was introduced. Within 40 years of its settlement, the Territory had become one of the most critically eroded sections in the country. Probably nowhere in the world has so much destruction occurred in so short a period of time. Because of this, the relation between land use and the processes of erosion are clearly defined. The region as a whole may serve as a warning of the rapidity with which erosion can destroy the agricultural value of land.

This publication shows that with an ingenuity developed by necessity farmers attempted to devise means for controlling erosion without interrupting crop production. A large number of the practices adopted did successfully check erosion until it increased to such an extent that it was beyond the control of individual farmers. Now that the Government, through the Soil Conservation Service, has initiated a coordinated attack on the problems of wind and water erosion, the experience of the earlier farmers in Oklahoma Territory assumes a new importance. It may serve as a check on current controlled experimentation, indicate the areal applicability of control measures, or in some instances indicate lines for further research.

H. H. Bennett.

THE HISTORICAL BACKGROUND OF EROSION IN OKLAHOMA TERRITORY

The first of the cattle drives across western Oklahoma [3] came in 1866. Thereafter thousands of cattle crossed the area annually. At first they merely grazed along the trails, but by 1875 ranches were established in the area. Within a few years after the extermination of the buffalo, cattle were more or less permanently pastured there. In 1883 the Cherokee Outlet and the Cheyenne-Arapahoe Reservation were leased to cattlemen, who probably stocked these ranges to their full capacity. Cattle were grazed illegally in other areas, such as the Kiowa-Comanche Reservation and Old Oklahoma (fig. 1).

Western Oklahoma was covered with a heavy carpet of grass varying in height from a few inches to higher than a horse's back. One of the early residents [4] of Old Oklahoma related that the grass on the upland was 4 feet high and that he had to stand up in his stirrups to see over the grass that grew in the valley bottoms in 1883. Although the grass farther west did not attain such height, the soil was protected from the wind and the rains by a thick sod. The great herds of cattle that were grazed in or driven over the area almost immediately after the Civil War at first seemed to have little effect on the plentiful supply of grass. Before 1890 the cattle were insufficient in number to deplete the grass to any extent. It is possible that some areas were overpastured, but an examination of source material fails to prove this.

During the cattle era homesteaders were barred from Oklahoma. Those who attempted to settle there were forcibly driven out. To the

[3] This study is a history of erosion and its control in Oklahoma Territory from the beginning of its settlement until the time when erosion became a major problem of western Oklahoma agriculture. Oklahoma Territory became a part of the State of Oklahoma in 1907, but because the more acute phases of both wind and water erosion developed shortly thereafter, the author has exceeded the time limit imposed by the title.

[4] Evan G. Barnard. Letter to the author from Enid, Okla., July 27, 1936.

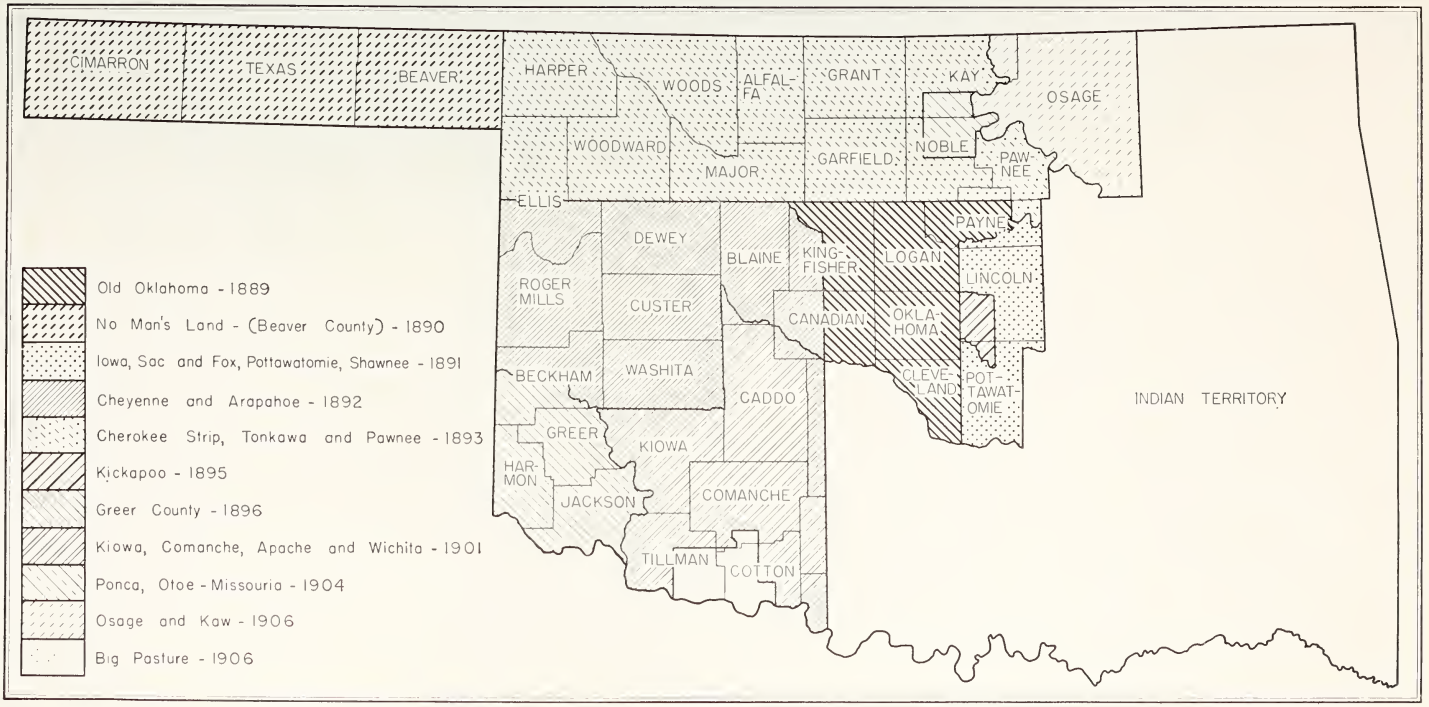

FIGURE 1.—Map of Oklahoma Territory showing dates of land openings.

potential homesteaders this seemed like discrimination since ranchmen were allowed to remain and since railroads were granted alternate sections along their rights-of-way. The glowing descriptions of the country further tempted the farmers.

> Glancing over thousands of acres covered with tall grass and dotted with groves, it appears the perfect counterfeit of cultivated fields and orchards. One can hardly persuade himself that he is not scouring a long-settled country, whose inhabitants have suddenly disappeared, taking with them houses and barns, and leaving only the rich pastures and hay-fields (*48, p. 70*).

Its beauties, the fertility of its soils, and its agricultural possibilities were extolled. It was prophesied that the next generation would see the valleys of the Canadian and Red Rivers converted into the "Rhine of America."

Pressure was brought to bear on Congress to cease its discrimination against the farmers and open this paradise to legitimate settlement. Eventually this agitation led to the successive opening of all of the Indian reservations. In 1889 Old Oklahoma was opened to settlement. The eager homesteaders thronged across the border, each selecting 160 acres. Ranchers still occupied the vast Cherokee Outlet, which they had leased from the Indians. The Cheyenne-Arapahoe lands, just west of Old Oklahoma, were opened in 1892 and the eastern part was immediately settled. Parts of Roger Mills and Beckham Counties in the west remained unsettled for a few years.

In 1893 the Cherokee Outlet was opened. This was the greatest land opening of all. The eastern part was quickly settled, while the western remained unsettled for a few years. Beaver County, also referred to as the Panhandle or No Man's Land, comprised the area west of the one hundredth meridian. Although it had been attached to the Territory in 1890, few homesteaders cared to settle there until the more humid land had been taken up.

Greer County, including the territory between the North Fork and the Red River, was annexed to the Territory in 1896 by decision of the Supreme Court. It had been pastured extensively while it was a part of Texas and had been cultivated to some extent prior to its opening. In 1901 the Kiowa, Comanche, and Wichita lands were opened to settlement. With each wave of land-hungry settlers, the ranchers were pushed farther and farther to the west. The western tier of counties and the Panhandle were the last refuge of the ranchmen.

Figures of the Land Office reveal that by 1902 most of the land outside of Beaver County, which then included the entire Panhandle, had been appropriated. Although livestock raising still constituted an important segment of the agricultural pattern, the number of range cattle decreased, the number of dairy cattle increased, and privately owned, restricted pastures replaced the open range. The intensive settlement of Beaver County came after 1904. In 1901 the greatest concentration of cultivated land occurred in the eastern part of the Territory. By 1910 most of the area was in farms. The extreme west end of the Panhandle alone remained principally a grazing country. As new settlers had little capital, they adopted a system of farming by which they could convert their labor into cash in a short time. The advice of farsighted individuals that much of the land was unsuited to cultivation was ignored.

The crop system employed was not conducive to soil conservation. Cultivation of corn, wheat, and cotton, the principal crops, caused

rapid deterioration of the soil and left it an easy prey to the ravages of wind and water. After a few years of cultivation, occasional farmers noticed a change in the composition of the soil. As the humus was destroyed the sandy soil became looser, more finely pulverized, and more susceptible to blowing. The tight lands grew more compact and less amenable to control. The relation of crop systems to the humus content of the soil is illustrated in two areas described by Fields [5] (*38*) in 1911:

> I know of one county where, because of its location and distance from market, the growing of feed crops and livestock forms the basis of the system of farming. Here these sandy soils actually appear to have increased in fertility . . . And in another county a little farther south, with good railroad facilities, the sandy soils have been farmed to corn and cotton and broom corn, no livestock has been kept, the crops have been sold for cash. Here there are many farms practically deserted because the winds during the last two exceptionally dry years have blown the sand about so as to make crop production almost impossible. Yet in this same county, many farmers who have farmed the sandy land carefully are prospering.

Although it was not adapted to the semiarid climate, the cultivation of corn spread rapidly over most of the Territory. In 1900 very little corn was planted in the western counties or the Panhandle but by 1909 the entire area was temporarily included in the Corn Belt. Comanche County alone had over 200,000 acres or about one-fourth of its total area in corn. The yields were usually low and during droughts the crop was a total failure. After repeated failures the more drought-resistant grain sorghums were introduced, of which kafir was the most popular. The long dry period following 1908 was partly responsible for this change. Like corn, these crops depleted the soil rapidly and were conducive to erosion.

In the northeastern part of Oklahoma Territory the most popular crop was wheat. Grant, Garfield, Kingfisher, Canadian, Oklahoma, and Logan Counties were the outstanding producers and had large acreages planted to wheat. Grant and Garfield Counties head the list. In both, the acreages increased consistently from 1900 to 1910, when they had respectively 129,947 and 132,538 acres in this crop. In Logan, Kingfisher, Canadian, and Oklahoma Counties a shift from wheat to corn and other crops occurred during this 10-year period. Large areas were also planted to wheat in the western counties.

The principal crop in the southwest was cotton. Although cotton extended in 1910 into the eastern part of the area little of it was planted west or north of Logan and Oklahoma Counties. It was concentrated in Greer and surrounding counties and in Comanche, Stephens, and Jefferson Counties. The campaign to reduce the cotton acreage, which grew out of the belief that a reduction in cotton production would mean an increase in price, was partially successful, but when certain farmers saw their neighbors reducing their cotton acreage they increased theirs in the hope of benefiting from the expected rise in price. Consequently the large majority of farmers retained the one-crop system in spite of warnings of disaster.

When it was evident that the one-crop system was not compatible with the interest of the farmers, when the lands began to drift and wash, when fertile hillsides were riddled by great gullies, some of

[5] John Fields was director of the experiment station before 1906 and later editor of the Oklahoma Farm Journal. He was the most important of the early soil conservationists. Many of the techniques reviewed in this study were his ideas or came from those who were stimulated by him.

the farmers thought, talked, and wrote of returning the land to livestock and grass. Few responded, and the majority of these only when poverty and mortgages were about to overtake them.

In the eastern part of the Territory, where the failure of wheat and cotton and corn was much in evidence, the number of cattle and hogs increased and some land was planted to grass and feed crops. Instead of carefully worked-out rotations, however, there was merely a shift to the production of feed crops. This was only a beginning—a new system of agriculture was needed to save the land, but the inertia of tradition militated against such a revolution.

Farmers were more interested in feed crops that would withstand drought than in those that would conserve the soil. Perhaps the most popular feed crop, aside from the grain sorghums, was cowpeas. They were also widely advocated and to some extent used for soil building. Cowpeas were adapted to any kind of soil and had a short growing period, which permitted their use in the summer as a second crop. Sometimes they were interplanted with corn, between the rows or sowed broadcast, but the proportion of such crops as cowpeas, peanuts, and other legumes was very small. Here and there farmers had worked out systems of rotation, most of which called for cowpeas once every 3 years or every alternate year.

Soil-building crops occupied a very small percentage of the total acreage under cultivation. In 1907 only eight counties had an acreage of more than 4 percent of the cultivated land planted to these crops. It is significant that the counties where erosion was first recognized (with a few exceptions) showed the highest percentage of soil-building crops.

Both the crop system and the farm practices in western Oklahoma were unsuited to the land. Plowing under of the stalks and trash to increase the humus content of the soil was seldom practiced. It was customary to burn off the land before preparing for planting in the spring, and before 1902 prairie fires were common. Undoubtedly this was one reason why the humus in the soil was so easily exhausted. The evils resulting from burning were considered by the Oklahoma Agricultural Experiment Station at Stillwater, and for years Fields and others preached against the practice, but with little effect. Farmers were entreated to turn under waste material, but for the most part entreaties failed.

> In spite of all that has been urged against the practice of burning stalks and trash, farmers continue to burn this vegetable matter instead of plowing it under. The evil effects of this practice may be seen on every hand. The light soils are blowing and washing away and the heavy ones are getting heavier and more compact each year . . .
>
> The past week I have been driving through a country largely composed of a light sandy soil, much given to blowing and washing. The farmers were busy burning the stalks and trash of all kinds and only in a few cases did I see fields where this matter had been turned under in season to have it well decayed by planting time. Many of these farmers are already ruined . . . One night I was able to drive without difficulty by the aid of light furnished by burning stalks and grass (*29*).

Among the outward signs of soil depletion and depreciated land values were poorly maintained farms with run-down houses and fences. Many farmers had no gardens, cows, chickens, or orchards, all of which are usually found on a well-cared-for farm.

In the beginning nearly all the farms were operated by the owners. In 1890, in Kingfisher County, 1,541 farms out of a total of 1,545 were

cultivated by owners; in Logan County 844 out of 849 were operated by owners (*74*). The whole area, however, is characterized by a progressive increase in tenancy. By 1900, in Lincoln, Oklahoma, Kingfisher, and Logan Counties the percentage of owner-operated farms had dropped to 50, 58, 67, and 59.8 percent, respectively. By 1910 it had been reduced to 46.8, 49.3, 61.2, and 55 percent.

The more western areas do not show tenancy to such an extent owing to their later settlement, but from 1900 to 1910 tenancy increased greatly. This increase was more noticeable in the cotton counties in the southwest than in the Panhandle and the northwest. In Harper, Woods, Woodward, Ellis, and Roger Mills Counties 76 percent or more of the farms were owner operated in 1910, while in the three counties in the Panhandle about 97 percent of the farmers were owners.

It was on the tenant farms that erosion appeared in its most critical state, because the interest of renters was focused on the crop rather than on the land. The agricultural system of the time in actuality placed a premium on soil destruction and a penalty on soil conservation. A program of soil conservation was not compatible with the greatest profits that could be derived from the land in a short period. The renter had, in many instances, mortgaged his crop and was forced to plant those cash crops that would pay the mortgage.

Oklahoma Territory was the last large farming area to be settled. Like other farming areas it experienced a shift from virgin fertility to soil exhaustion, but in no other section was the transition so rapid. The settlers superimposed upon this semiarid area agricultural systems developed in the more humid East. The rainfall of the last 5 years of the nineteenth century was, in general, above normal. New methods of cultivation were devised for conserving the moisture in the soil. The combination encouraged the westward extension of agriculture in an area best suited to grazing. The native sod was destroyed and the land began to drift and blow. Although the rainfall was scant, a large part of it was normally concentrated in the spring and early summer months and frequently occurred in heavy downpours. The result was soil washing and gullying. When droughts occurred, there were crop failures. Within 40 years after the opening of Oklahoma a serious erosion crisis had developed. The Panhandle is now a part of the "dust bowl" and the sand hills of the Blackjack section in central Oklahoma now constitute one of the largest contiguous areas of serious gullying and sheet wash to be found within the country.

WIND EROSION

EXTENT AND RECOGNITION

Wind erosion in western Oklahoma before 1900 assumed the form of local drifting and sandstorms.[6] The sandstorm of the Great Plains was recognized long before the opening of western Oklahoma

[6] Blowing of sand along the dry and spreading river beds of the Canadian and Cimarron has no immediate connection with the blowing of sand caused by the breaking of the sod. The nature of the western rivers is such as to leave large areas of sand and sand dunes exposed to the sweep of the winds. These local disturbances of the mobile sand along the river beds remain of minor importance. Not until larger and larger areas of native sod were turned and the denuded ground was left unprotected against the ceaseless sweep of the winds did the sandstorm become significant.

in the nineties. In North Dakota it had made its appearance 6 or 8 years after the land was broken, but in Oklahoma Territory it appeared almost from the beginning of settlement. Dust storms and sandstorms, unlike the slow wasting of soil by water and the almost imperceptible beginning of local drifting on sandy land, were too conspicuous to be ignored.

Not only were the farmers of the sandy plains engulfed in the "sand simoons" but the people of the newborn cities also felt the full impact of the blowing dust. Indeed it is upon the lamentations in the newspapers of the urban areas that we depend for early records of dust storms.

Although the storms make their appearance in normal years, they are less intense and less extensive than in periods of drought. There were three droughts within the period under consideration. The first saw the rise of sandstorms from 1890 to 1896 and a gradual decline until 1901, when seas of dust became common to the area once more. With the wet years from 1905 to 1908 these storms subsided somewhat only to reappear in 1909, the beginning of the third dry period.

Some of the most severe sandstorms occurred at very early dates and it is evident that they were in part caused by the transportation of dust and sand from outside areas. The opening of the Cherokee Outlet in 1893, although its 6,000,000 acres had not been disturbed by the plow and although Old Oklahoma had been settled barely 3 years, was accompanied by an intense and extensive sandstorm which began about September 10 and lasted for 2 weeks. One storm followed another in rapid succession and the treeless plain offered no protection to the settlers. The dust was so thick that a person could not see 20 feet in front of him. At Perry it was reported that several thousand people were forced to leave the town. A heavy rain finally put an end to the storms.

In 1894 the sandstorms began again and recurred during several successive years. Reports for the years 1893, 1894, and 1895 are numerous. The sandstorms usually began in March or April and lasted for several days. Often they continued intermittently during the summer and into the fall. An April dust storm of 1895, accompanied by a 40- to 50-mile wind, evidently covered several counties. Clouds of dust obscured the sun and it was impossible to see halfway across the street. According to local newspapers this was one of the worst storms ever experienced.

Frequent dust storms occurred in 1896, beginning in April and recurring several times during the summer and in September. The first evidence of drifting is recorded (*1*) in the spring of that year in Logan County. During the week ended Monday, April 13, high, southerly winds prevailed every day, filling the air with sand and dust and covering fields of oats, wheat, and corn.

The dust storms of 1897, 1898, and 1899 were less intense and of shorter duration than some of the earlier storms. The decrease in the number of storms after 1896 was commented on in local papers.

The dry period 1901–4 brought an increase in dust storms. In 1901 and 1904, especially, they were observed in the eastern part of the Territory as well as in Woodward, Greer, and Comanche Counties. The area affected by sandstorms was more extensive than at earlier dates. Although there are reports from only nine counties for this

period their wide separation indicates that the storms extended at times over most of the Territory. We are dependent for sandstorm data on local newspapers, and because files are scarce, data are very spotty. That newspapers were more numerous in the central areas accounts for the fact that sandstorm reports are largely limited to Logan and Oklahoma Counties. Wherever newspaper files are available, descriptions of local sandstorms are found. In Cleveland County the storms seem to have been particularly severe. At 9:30 on the evening of March 2, 1904, a bad storm blew up without any warning and continued until daylight. The air was filled with dust and it was almost impossible for the people to remain out of doors. The fact that dust storms came first from one direction and then from another received comment (*2*).

After blowing all the red dust from Southern Oklahoma through this city to the northward, Old Boreas suddenly changed his mind, last night—also the course of the dust—and hurled the entire lot of pulverized real estate back south. The dust came so thick for a few minutes that it was impossible to see half a block . . .

FIGURE 2.—Local drifting began almost imperceptibly and finally merged with regional blowing.

Concomitant with the rise of the dust storms came the local drifting, which began imperceptibly and finally merged with regional blowing (fig. 2). Drifting is to be distinguished from the sandstorm, which has occurred almost from the beginning of settlement. Yet the two are in a sense one and the same problem. The dust storm was formed from the upper part of the mobile soil. As the particles of soil became lighter, devoid of the humus that bound them together, the tiny, loose particles not only rolled along on the ground, but also drifted onto fields, ascended high into the air, and were transported over wide areas.

The drifting of the soil, though it had been recognized as early as 1896, was not considered an important problem until the dry year of

1901. Then drifting became increasingly common and the years of intensive cultivation began to bear a harvest of shifting sand. Farms that had never before experienced blowing now suffered severely.

The extent of land subject to wind erosion was variously estimated. According to Fields, sandy lands comprised approximately one-third of the area of Oklahoma, and a farmer in Major County estimated that one-fifth of the land in the State was subject to blowing (*24*). A much larger proportion of the area under consideration was subject to wind erosion as there was little drifting in the eastern part of the State.

As more and more of the land became subject to blowing, wind erosion assumed greater importance in the minds of the farmers of the West. It was considered of paramount concern to some of them and to the editors of farm journals by 1910. Farmers here and there reported that large areas of land were eroded by the wind and that drifting and blowing had increased to an unprecedented extent. In wheatfields soil was blown away to the full depth of the plowing and piled up in stalk fields to a depth of 6 to 18 inches.

By utilizing the data available,[7] it is possible to compare and contrast periods of relative dryness and wetness with the degree and extent of wind erosion. Reported cases of drifting from 1890 to 1914 indicate that during dry periods drifting was greater than in wet years.

There are 56 reports of areas where drifting had become a problem during the period 1909–14. This was a period of relatively light precipitation. During the period of greater rainfall (1905–8) only six cases were reported. Thus for a period of 6 years there are more than nine times as many complaints about drifting as in the preceding 4-year period. The records for Kingfisher show precipitation above normal for 1907 and 1908. It is significant that there were no reports of drifting during this time. But from November 1908 to February 1913 there were long periods of drought broken by short periods of intermittent rainfall. From November 1909 to June 1911 there were 20 months of below-average rainfall interrupted only in August and February. This period was characterized by much drifting in the area. Wind erosion seems to have invaded rapidly areas that were not normally susceptible.

There were nine reports of wind erosion from 1901 to 1904, during which time large areas of the extreme West were not as yet under cultivation. There were only six reports for the following 4 years. Owing to the increase of settlement, the better dissemination of information, and the disposition of the farmers to carry their troubles to the farm editor, an increase in reports of erosion troubles might have been expected. But as a matter of fact the number fell off 50 percent. This was because 1901–4 was a more or less dry period, and 1905–8 was a wet period.

[7] Farm journals of the period were the source of the reports. The fact that the circulation of farm papers was on the increase partially vitiates the significance of the increased number of the reports. Also, in the later period, the farmers being more familiar with the area were quicker to report their wind-erosion problems. And then as the work of such men as John Fields became better known it is probable that a larger proportion of the farmers reported such difficulties. However, in spite of all these factors, the discrepancy in the number of cases reported for the later period as contrasted with the 1905–8 period indicates that wind erosion steadily increased in extent and intensity except during years of more than average precipitation.

In Oklahoma City there were 8 consecutive months of below-normal precipitation from June 1900 through January 1901. Preceding July 1902, there were 11 months below average and from April 1903 to June 1904, 12 months. At Guthrie the precipitation for the period October 1900 to March 1902 was below normal except for the month of August 1901. These dry periods were all accompanied by much drifting of the soil.

In Comanche County there is evidence of drifting during dry periods. From September 1900 to March 1902 there were 17 months with precipitation below normal and from March 1903 to June 1904, 14 months. The conclusions of both these periods were characterized by drifting and sandstorms. No cases of either drifting or storms were reported in this county in the wet period of 1905–8.

Only a slight decrease in precipitation in extreme western Oklahoma and the Panhandle caused drifting. Weather reports from Woodward indicate this. The records show only a small downward deviation from normal from February 1909 to December 1912 with occasionally several months of more than normal precipitation. In this section and neighboring counties we find that drifting rapidly increased. The same is true of Beaver County during this period. From February 1908 to November 1909 the trend of precipitation was generally downward with several minor interruptions. It is significant that in 1908, though it was very wet in most of the area, it was somewhat drier than usual in the western tier of counties and in these are found the only reports of drifting for that year.

In western Oklahoma the soil was originally held in place by the sod. Under cultivation the sod was broken and the humus content of the soil reduced. The situation was aggravated by the custom of burning off the land before planting. After some years of cultivation, the soil was finely pulverized and its humus largely destroyed. Even the heavier soils were reduced to a powdery condition and became susceptible to erosion by both wind and water.

Sandy soils are particularly susceptible to drifting, and the soils of certain areas early became known as "blowy." This was true of the soils of Beckham and Greer Counties and of parts of the Blackjack section. By 1914 wind erosion affected at least 26 counties in western Oklahoma. Of these Blaine and Logan were affected before 1900 and Greer, Comanche, Oklahoma, Kingfisher, Woods, Roger Mills, and Washita by 1904.

Some types of soil showed signs of blowing only after a long period of cultivation and then only during extended dry periods. Others deteriorated rapidly into "blow sand," fit only for scrub vegetation. Each piece of sandy land presented the man who cultivated it with a new problem every year.

Drifting soil frequently covered entire fields and completely destroyed the growing crops. In addition, the force of the blowing sand in the spring was often great enough to cut down the young plants, especially alfalfa. In Major County the destruction of alfalfa was known to have occurred in three different years on the same field.

In some sections wheat also suffered greatly in dry years. Numerous farmers from Texas County complained of wheat blowing out of the ground. In many places all the loose soil was blown away, leaving the hard unturned ground exposed. Similar conditions pre-

vailed in Greer County from 1902 to 1906. One farmer stated (*27, v. 14, no. (14)*) that twice within that period crops had been damaged by strong northeast June winds. Thousands of acres of cotton were destroyed and nearly every field that had been broken flat and planted level was ruined. Fields that were listed and then harrowed or that were plowed shallow were slightly less seriously damaged.

In a survey made in 1910, Fields (*36*) observed that many of the farms in Roger Mills County between Cheyenne and Roll were damaged by wind; a number had been deserted by discouraged homesteaders and converted into pasture. Later he reported (*38*) that in western Oklahoma many of the farms were deserted because wind erosion had made farming almost impossible. Near Hooker some of the farmers had lost two-thirds of their wheat crop in 1909 because of wind erosion.

The more progressive farmers realized that fighting blowing sand was a steady job over large areas in western Oklahoma. However, most of the farmers continued to crop the same land to cotton, corn, or wheat year after year, leaving it bare and fully exposed to the wind during the winter months. By the beginning of the century it was felt by some farmers that breaking the sod was a mistake. But after this time, extensive grassland areas were put under cultivation. Every year saw more sandy land broken by the great mass of farmers and newcomers, with a proportionate increase in erosion.

VEGETATIVE CONTROL

With the plowing of new land and the progressive destruction of the sod by cultivation, soil blowing increased rapidly. The soil became lighter in color, finer in texture, and tended to blow more readily. The stages in the process of deterioration were early recognized, and by 1900 Ten Eyck (*71, p. 541*) tried to impress upon the farmers the seriousness of the situation.

> When the wild prairie is first broken, the soil is mellow, moist and rich, producing abundant crops. After a few years of continuous cropping and cultivation, the physical condition of the soil changes; the soil grains become finer; the soil becomes more compact and heavier to handle; it dries out quicker than it used to; bakes worse . . . After a soil has been cultivated and cropped a long time, it tends to run together and is very sticky when wet, but when dry the adhesive character disappears almost entirely. The grass roots which formerly held it together are decayed and gone, and now when loosened by the plow it is easily drifted and blown away.

Something was needed to take the place of the natural vegetation, which had maintained the humus content of the soil and prevented blowing. Effort was made to solve the problem by various methods of plowing and cultivating, but these alone were inadequate. A fundamental change in the cropping system was essential; soil-building crops had to be substituted for the usual cash crops.

> The class of crops most neglected in this State are the grasses and legumes. When the soils of Oklahoma were first broken they were filled with a large quantity of vegetable matter, as a result of the long growth of grasses. The vegetable matter is of great importance, yet it is being rapidly destroyed by the present system of farming. Soils that did not blow when they were first broken begin to blow after several years of cropping, due to the reduction of the vegetable matter present (*78*).

It was also felt that crop rotation should form an indispensable part in adding or holding the humus in the soil. The following rotation was highly recommended: First year, kafir; second year, corn with wheat or rye planted between the rows with a one-horse drill; third year, wheat or rye with the grain cut as high as possible, followed by cowpeas the same year.

Green manuring was regarded as essential by some farmers, and such crops as cowpeas, oats, sweetclover, sorghum, and rye were used. Of these, sorghum was the most popular. It was considered advisable to turn it under in the early fall while it was still green so that it would rot quickly. A second growth, following the removal of the first, supplied the soil with organic matter.

Other crops, such as cowpeas, were planted for the triple purpose of holding the soil, renewing the humus, and increasing the fertility. These could be planted in alternate rows with corn, sowed with corn, or produced as main crops or as catch crops. If planted as a catch crop they were pastured somewhat and turned under while green.

Manuring, while not stressed in farm journals, was the most widely used method of soil building.

> The addition of vegetable matter which stable manure supplies is of greater importance to Oklahoma soil. It is a common experience with sandy soils that they blow more readily than when first broken out and many wonder why. Continued farming without putting anything back has resulted in the decay and disappearance of the vegetable matter in the soil. When the land was first broken out, this humus filled in the chinks between the sand grains and pasted them together. The land worked better, held moisture better, didn't wash so badly, and produced heavier crops. But such soils after several years of farming without manure are approaching the condition of a sand pile . . . (*33*).

The manure was spread on the land in the winter and turned under. If the soil was blowy, it was left on the land until spring. Sufficient quantities of manure would prevent blowing, but this was not available on the average farm. There was some prejudice against the use of manure in dry seasons because it tended to burn the crop if spread too thickly. Bishop (*18*) claimed, however, that this objection did not hold true on sandy land.

All of the measures described aided in the building up of the soil but the first consideration was to hold the soil in place during the process. To this end cover crops of all types were employed—wheat, rye, oats, barley, vetch, alfalfa, grasses of all kinds, grain sorghums, cowpeas, peanuts, sweetclover—and a variety of dead covers such as straw and stalks. Of these covers grass was probably the most effective.

COVER CROPS

GRASS

By 1902 the rapidly diminishing acreage remaining in grass had induced a serious pasture shortage. The overgrazed and depleted native grasses, even when not plowed, became progressively poorer in quality. Blowing, further accelerated by several dry years, became critical in some sections by 1904. As early as 1900 Ten Eyck (*71*), of Kansas, had advised the Plains farmers to go back to grass. But the native grasses were gone in some sections and the barren spots could not be resodded except over a period of years, and then with difficulty. The only alternative was a quick sodding with tame grasses. Bermuda grass, the hardy perennial, was frequently sug-

gested as the only thing that could save the sandy land farmers (fig. 3).

Fields started in 1902 on his long crusade for Bermuda grass. As director of the Oklahoma Agricultural Experiment Station and as contributing editor of the Oklahoma Farmer, he wrote articles urging that whole farms be set in Bermuda grass. After 1906, as editor of the Oklahoma Farm Journal, in almost every issue, he advocated Bermuda grass as the "farmers' way out." Fields' crusade for Bermuda grass was mainly for the purpose of preventing water erosion on washy land,[8] but he also advocated it as useful in the control of wind erosion. Many of the farmers in western Oklahoma, and even to some extent in the Panhandle, set out Bermuda sod and found it very satisfactory.

FIGURE 3.—Bermuda grass was recommended as a solution of the problem of "blowy soils."

My Bermuda grass did not start until the last of April. (It was set with sods in the spring of 1902 and did well.) I thought it was all winter-killed so plowed it up and put it to alfalfa. We live in a sandy land seven miles west of Cordell, Washita county. The wind blew nearly every bit of the alfalfa out but the Bermuda grass is fine (August 10, 1903) . . . (*53*).

But the dry years of 1909–11 combined with cold winters eliminated Bermuda grass from the Panhandle and from other areas in western Oklahoma. The failure of Bermuda grass was reported from practically all of the counties in northwest Oklahoma.

Other grasses were tried with varying degrees of success. A few tried Colorado grass; others experimented with crabgrass; and Johnson grass, detested by southern farmers, grew to be fairly popular as other grasses became scarcer or failed. But because of the law prohibiting its importation and its reputation as a pest, Johnson grass was not widely used. Some farmers who experimented with it found that it deteriorated or died out when pastured or not culti-

[8] This subject will be treated more in detail under water erosion.

vated. However, others claimed it could be used advantageously as a cover crop or interplanted with other crops.

An oat or wheat crop can be raised on Johnson grass land and leave the grass in better condition for hay than not plowed at all. In fact, to keep a good stand of Johnson grass it must be plowed every year or two. But the greatest feature is keeping a coat of vegetation on the land so corn, wheat, and oats can be planted at the proper time without being blown out. I would much rather cultivate a corn crop in Johnson grass than on the bare sandy soil. So many of our sandy farms are deserted, and great localities are almost worthless on account of becoming bare of vegetation and the winds whipping out the crops; when in fact, these lands are very valuable if properly managed (*44*).

About the time Bermuda grass was frozen out, Colorado grass was introduced. Information concerning it is scanty, but there is reason to believe that after the dry years of 1909–11 it proved superior to Bermuda grass. In 1912 Vining of Erick, Okla., wrote (*75, p. 7*):

I have been experimenting for several years to find a winter cover crop to prevent my land from drifting. I tried burr clover, winter vetch, and rescue grass, all three of them a winter growth in the south, reseeding themselves in the spring, and coming again in the fall. None of them made satisfactory growth for me. Besides I find it is often too dry in the fall for seed to sprout, so I am convinced if we have a cover crop, it must grow immediately after the crop is laid by, while the summer season is in the ground . . .

I believe that I can take the average sandy land of Western Oklahoma and with Colorado grass as a cover crop, I can work out a system of farming that will prevent the land from drifting.

Bentley, State agent of the Farmers' Cooperative Demonstration Work, also pointed out the advantage of Colorado grass (*16*). It was an annual that reseeded itself every year and not only yielded several cuttings of hay a season, but also protected the soil against blowing during the winter and spring.

Crabgrass, unlike Colorado grass, was not new to the region. It is interesting to note that this annual, which appeared promiscuously in most parts of the State and was considered a pest by Oklahoma farmers, was later acclaimed as the one and only method of checking blowing.

Fields considered crabgrass a blessing on sandy lands, and regretted that many farmers, not recognizing it as such, carefully raked it together and burned it. He (*39*) advised that it should be left standing between the lister furrows until the crop was well established and later worked into the soil so that the decaying vegetable matter might serve to reduce blowing. Crabgrass was used in orchards where many other grasses either would not grow or tended to smother out the trees. Orchards planted in sandy land suffered much from blowing and wasting of the soil. It was recommended that the land should be covered with some kind of growth during the fall and winter. Crabgrass was available and served well to check both washing and blowing.

ALFALFA

Alfalfa also was used as a cover crop. It was especially popular because hay produced from it was of excellent quality and several cuttings a year could be obtained from the same land. Editors of farm journals urged repeatedly an increase in the alfalfa acreage and farmers found that if a good stand of alfalfa was once established, the soil would not blow, no matter how sandy it was. Farmers often struggled for years to get their sandy land set in alfalfa. It was found that fall, winter, and spring winds were frequently strong

enough to blow the alfalfa out of the ground. If they succeeded in getting a good stand, it was often cut to pieces by blowing sand. One farmer planted alfalfa three times on 18 acres of his land. It was sown in the fall and each time was thriving well the following February, but the crowns were later cut off by the sand carried by the high, dry winds of March and April (*43*). In the end the farmer had but 2 acres in alfalfa.

Other farmers reported similar experience. It was soon realized that because of the slow growth of alfalfa, some kind of nurse crop was necessary on sandy land. Various crops, including wheat, oats, sorghum, and kafir, were sown at different seasons of the year to help the young alfalfa plants to gain a foothold in the shifting sands. Some tried manure, trash, straw, or stubble, pressing them into the soil with a disk. Possibly sorghum was the most widely used nurse crop. The farmers were advised to plant it in the spring and leave a stubble 5 or 6 inches high when cutting it in August or September. The alfalfa was sowed without destroying the stubs because the sorghum produced a second growth which shielded the alfalfa from the wind. If the second growth started late enough, it did not smother out the alfalfa but was killed by the early frost and stayed on the ground all winter and spring. It was also recommended that alfalfa be preceded by sorghum, broomcorn, or other crops, which were to be turned under while green.

Oats were sometimes used, because, like sorghum, they are killed by the cold weather. The dead straw protected the ground all winter. In March alfalfa was sowed in the dead oats with a disk drill, care being taken not to disturb the soil more than was necessary (*40, p. 61*).

It was also recommended that oats should be sowed in the spring along with the alfalfa seed to prevent blowing. Sometimes grain crops and alfalfa were drilled in alternate rows. Later the grain crop, having accomplished its purpose in protecting the alfalfa, was destroyed by cultivation. Stubble of any kind was a favorite type of protection. If the land had been in wheat or oats, the mower blades were raised 4 or 5 inches, leaving the stubble high enough to protect the land during the winter. Alfalfa was sowed the following spring. When alfalfa was planted on corn stubble, the stalks were either left standing or cut high. Kafir and other stalk crops, such as milo and sorghum, were used in the same manner, except that the latter crops put on a second growth, which necessitated late cutting. When alfalfa was planted on cotton stubble, a small-grain crop, such as rye, wheat, or oats, was sowed first, the ground later being put in alfalfa.

Occasionally alfalfa was sowed on chopped sod that had been disturbed only by disking. The native grasses, usually in a depleted condition, did not seem to interfere with the growth of the alfalfa. For sandy land this method was recommended because the soil did not blow so readily as did land that had been cultivated.

COWPEAS

Cowpeas, another leguminous crop, were universally recommended as a soil builder and became one of the most widely used legumes in western Oklahoma. Ordinarily they were planted not to hold the soil but to build it up. Old, worn-out fields could produce a crop

when nothing else would grow. Cowpeas not only increased the fertility but decreased blowing by adding to the humus in the soil. Farmers and editors recommended that they be planted at least every third year to arrest the declining fertility caused by successive crops of corn, wheat, or cotton. As a mixed crop, cowpeas were probably used more than any other crop. They were planted with corn in alternate rows or interplanted in the row after the second plowing or when the corn was laid by.

Cowpeas produced abundant vine, almost covering the ground, and, if left uncut on the land during the winter, protected the soil admirably.

> Leave a cover crop of peavines on the land through the winter and when spring comes you may have some of your neighbor's soil but he will have very little, if any, of yours (*70*).

As a summer crop, cowpeas covered the ground and prevented the summer and fall winds from blowing the loose soil away. They were also used in orchards when other types of cover were inadvisable.

In the sand hills it was difficult to keep the soil from blowing from around fruit trees. Some farmers solved this problem by plowing and cross-plowing their orchards and then drilling one-half bushel of cowpeas to the acre in June.

Some farmers, however, quit raising cowpeas on blowy land, because they claimed it aggravated drifting. The drifting was probably due to the low organic content of the soil and its powdery condition, and if the cowpeas were taken from the ground for hay, the soil was left exposed.

SWEETCLOVER

Sweetclover was tried at various times and places in western Oklahoma, but it was never popular, being used chiefly for bee pasture. It was sowed on sandy stalk land, and occasionally it was planted as a substitute for the depleted native grasses on thin sandy land that had never been broken by the plow. When Bermuda grass was killed out in 1910 and 1911, sweetclover increased somewhat in popularity. Though it was used chiefly as a crop to be planted on thin sandy land and later to be turned under to enrich the soil, it was also recommended to prevent blowing, especially on the blow soils north of the Cimarron River.

OTHER COVER CROPS

Wheat, rye, and oats, as well as legumes, were occasionally used as cover crops. There was difficulty, however, in getting a stand of small grain crops on sandy land. One winter the terrific winds blew out the wheat after it was sowed, whipped off the snow, and then the plowed soil. This occurred in a number of fields in different sections.

If once a stand of wheat or rye could be secured, it proved satisfactory as a cover crop. In some instances wheat or rye, sowed on land after cowpeas had been removed or planted on sorghum stubble, checked blowing. An Ellis County farmer suggested sowing wheat in the fall as a remedy for blowing. This worked until a fall occurred that was so dry and windy that the seeds blew away before they had time to sprout and fasten roots into the sand.

Oats sowed in the fall served primarily as a cover crop. The dead stalks were plowed under in the spring, and humus was added to the soil. Besides being used as a protective crop for alfalfa, they were suggested as a cover for orchards, to hold the soil during the winter. On very sandy land, however, it was stated that oats would not grow.

There is little evidence that the small-grain crops were used to any great extent to prevent blowing. Lack of fertility prevented the production of a good crop, and there was a tendency for the seeds to be blown out of the ground before they sprouted.

Farmers were more successful with sorghum and kafir. Sorghum was used extensively both as a nurse crop for alfalfa and as a cover for the land. It could be harvested in the late summer, leaving a high stubble, and the second growth left to protect the soil during the winter. Later when winds were not so high, it could be plowed under.

Kafir had the specific advantage of growing well on sandy soil. One farmer who had lost an entire crop of wheat on his sandy farm resolved to plant it all in kafir to stop the blowing. After the drought years, kafir replaced corn to a great extent and was highly recommended both as a feed crop and to hold sandy land.

> This plant on gravelly points and gyp hills that would not yield enough to feed a goose will make a fair yield, both of grain and fodder. Planted on light sandy soils so loose and deep that nothing but a mortgage will hold them, it makes a good yield, and the stubs or stalks left standing keep the soil from blowing during the winter and spring months (*49, p. 17*).

Sundry other cover crops and even weeds were used by the western Oklahoma farmers to hold their land. Milo was used in the same way as kafir. Crawford (*27, v. 12, no. 9*), a farmer in Greer County, contended that it would "keep the softest sand from drifting." He also used Mexican beans on sandy land where the wind had blown away the kafir. One of the weeds which took the place of the native grasses was the Russian-thistle. Although a pest, it was considered better than nothing to hold the soil.

Sometimes crops were planted together to prevent blowing and not merely as nurse crops to protect alfalfa or wheat. Kafir and cowpeas were planted in the same row, milo and cowpeas were mixed, or different crops would be planted in strips to control both water and wind erosion. Strips of native meadow or tame grass sod were left at intervals between cultivated crops. The experiment station suggested that for blowing soils it was advisable to plant the corn in narrow strips extending north and south across the farm. Grass fields or meadows were to be placed between the cultivated fields to check the movement of the soil. It was recommended that 10 rows of kafir or milo be alternated with 10 rows of some other crop. On a field with blow sand, it was advisable to plow in the spring and seed immediately. The alternate strips of cultivated and shallow-rooted crops tended to stop the drifting (*77*).

DEAD COVERS

Stubble, stalks, trash, straw, and manure were known as dead covers. In general, fall plowing was dangerous, and the farmer was forced to leave his land undisturbed if he could not get some kind of cover crop on it. Frequently the land was left bare except for the stubble, cut purposely rather high. If some winter crop, such as

rye, was not planted on the stubble in the fall, the next year's crop was often planted on it without turning or listing. In this way trouble with blowing could be checked on land that had formerly drifted. In another instance the kafircorn stalks were stripped and the entire stalk was left in the field.

It had long been the custom for most western Oklahoma farmers to burn off their fields, carefully raking into piles and burning the stalks, dead grass, and other crop remains. Fields (*35*) criticized this procedure:

> Weeds and grass and cornstalks had been carefully raked together on some of the sandy bottoms and sloping lands and were being burned to get them out of the way. And this spring the sand will blow a little more than it did last year and damage the crop a little more, all because the man who farms the land refuses to use the means to improve the soil which Nature provides.

The destruction of trash not only caused blowing by reducing the humus in the soil, but also left the ground exposed to the wind. Leaving all the trash such as stalks, weeds, grass, and stubble on the land was one of the best ways to hold the sandy land.

Scattering straw on the land was widely recommended as an erosion-control measure. Rotten straw was scattered with a manure spreader, followed by a disk harrow with the disks set nearly straight so as to press the straw into the earth. Care was taken not to scatter the straw too thickly lest it smother the plants if a growing crop were on the land. This method was rather expensive, and only a small area could be covered.

Manure distributed evenly on top of the ground was also used to prevent blowing and was considered a good control measure even on blow sand. Coarse manure was put on as heavily as possible where the wind was strong. Then a weighted disk harrow with the disks set straight was run over the land to prevent the manure from being blown away. Frequently in conjunction with these methods the livestock were pastured on the land so that their manure would help to stop the drifting, but the constant treading increased the danger of erosion.

WINDBREAKS

Before attaining statehood, Oklahoma Territory had thousands of acres of planted forests. It was said in 1904 that Oklahoma had set the example for the rest of the Plains country, had converted the barren waste of prairie into an artificial forest (fig. 4), and had revolutionized the climate of the semiarid belts (*5*). The early experiments in tree planting were largely motivated by the belief that forestation would increase the rainfall. Although this theory proved to be false, the early tree planting paved the way for the use of windbreaks. In the early years the planting of windbreaks to control drifting was seldom mentioned, but from 1904 to the present day, windbreaks as means of protecting the sandy-land farms have received much publicity.

The experiments of farmers in raising trees were, for the most part, successful. Although some of them died, thousands of trees set out in the western tier of counties lived and throve. Only in exceptional instances were the trees watered. Care was taken, however, in getting them started; a good seedbed was prepared, and the trees were carefully cultivated.

The experience of a farmer of Texas County (*45*) is representative of the general status of tree planting. In 1905 he set out 7,000 trees and during the following 4 years lost only 20 percent. The trees were planted in two parallel 12-foot strips, one along the southern edge and the other through the center of his quarter section of land. The ground was prepared by deep breaking and several successive harrowings. On the two strips he planted rows of cottonwood, catalpa, mulberry, black locust, ash, and elm. After each rain they were cultivated with a 14-tooth cultivator. During the first year the cottonwood made the best growth, but at the end of the third year the various species ranked as follows: Black locust, cottonwood, catalpa, mulberry, ash, and elm. The locusts and the cottonwoods had attained a height of from 8 to 12 feet. The mulberries were regarded as almost useless because they were often killed to the

FIGURE 4.—A Caddo County farm in 1903, surrounded by thriving year-old trees, which are almost concealed by grass. (Photo by U. S. Forest Service.)

ground by late frosts, but, if planted as hedges, they served to catch the blowing sand. The leaves of the catalpa were frostbitten as many as three times during a single season.

The experiment station (*62*) recommended a windbreak consisting of three parallel hedges about 7 feet apart, a row of Osage-orange or tamarisk, a row of Russian mulberries, and a row of black locusts. The black locust was one of the most successful of the trees grown on the Plains. Experience at the experiment station indicated that Russian mulberry and the cottonwood also grew well on sandy lands, but that catalpa was a disappointment except on good soils with an open subsoil.

Thoburn (*72*) was also an advocate of windbreaks for the sandy farms.

> The windbreak also tends to minimize the drifting of soil, in which there is an excess of sand, during seasons of high wind. This is important for some of the most valuable soils in Oklahoma are sandy loams . . . On one farm in Washita county, where the ravines cut deeply into the red clay, I noticed that trees of several species had been planted in the bottom of such gullies. Thus,

what had been an useless and unsightly ravine, had been transformed into a beauty spot and also gave promise of beneficial returns in the future as well.

He also recommended Russian mulberry, black locust, tamarisk, and hackberry for the uplands, and black walnut, red and white elm, and ash for the bottoms.

On the basis of the experience of farmers, Fields worked out a design for properly constructed windbreaks, which he published in the Oklahoma Farm Journal. He said in part (*37*):

> . . . if I had one of these sandy land farms, the first thing I would do would be to plant a windbreak the full length of the south line. On the line I would set a tamarisk hedge. Four feet from this would be set a row of Russian mulberry trees about six feet apart; then six feet from this, a row of black locusts; and six feet from this, a row of cottonwoods. The locust and cottonwoods would be about six feet apart in the rows, set to break joints. And in a very few years, there would be a solid belt of foliage which would force the wind upward and protect the sandy soil for an increasing distance to the north each year. As soon as I could a similar row of timber would be set east and west across the middle of the farm, and later, two more rows splitting the eighty-acre pieces east and west. This would give four forty-acre strips across the farm, each a little less than forty rods wide, protected from the sweeping force of the winds. Without some such protection there will be an annual battle with the winds and drifting sands . . . Let's solve this problem of the sandy lands of Western Oklahoma.

Windbreaks of from one to three rows of trees placed on the south side of fields were recommended but farmers were cautioned not to plant more trees than they could tend.

Trees were used not only around or across farms to break the force of the wind but also to shelter orchards.[9] Frequently small orchards were surrounded with catalpa, locusts, and Russian mulberry. Fields suggested that the Russian mulberry be planted on the outside and two parallel rows of black locusts 6 to 8 feet apart inside. The trees were to be set 4 to 6 feet apart, "breaking joints." For an open subsoil catalpas were recommended as superior to locusts. This was because the locusts tended to sprout for a considerable distance around the tree. The experiment station (*62*) advised that the orchard windbreak should be taller than the fruit trees and should therefore be planted 2 or 3 years earlier.

Hedges were also used for windbreaks, a few having been planted as early as 1900. In 1912 an article on the proper method of planting appeared in the Oklahoma State Farmer. The following is an excerpt (*22*):

> For hedge purposes it is always better to plant a double row of plants, whatever they be, alternating the plants so that the plant in one row will be opposite the space in the row alongside. The rows should be about one foot apart and the plants about eighteen inches apart in the row.
>
> To get a good hedge it is absolutely necessary to cut it back for the first few years and make it thick enough below; otherwise, it is apt to become toppy and die out below so that you can see through it. In fact, no hedge is satisfactory unless it is trimmed. At the end of the first year a privet hedge should be cut back to within one foot of the ground, and at the end of the next year it should be cut back to the height desired, usually about three feet. After this it should be kept trimmed on top so as to make it broad and low, and be careful not to trim the sides very much, as most people are inclined to do.
>
> We have found in this neighborhood that the tamarisk makes a much better hedge plant than either the California or the common privet.

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[9] Since much drifting occurred in orchards where many cover crops were inadvisable, it is reasonable to infer that the windbreaks were used to protect the soil as well as the fruit trees.

Although some trees died during dry periods, most of them successfully weathered the droughts. This may have been the result of spotty rainfall, more favorable soil type, or greater care in planting and cultivating. Catalpas planted in Tillman County in 1907 throve in spite of the long dry period beginning in 1909. It was also claimed locally that the catalpas, black locusts, and maples that died in 1910, failed because of lack of cultivation since others that were carefully tended continued to thrive.

Where windbreaks were properly designed they proved successful in protecting the sandy land from wind erosion. Although records concerning the use of windbreaks in erosion control are scant, it is evident that, as other methods of control proved inadequate, the use of windbreaks increased. Their popularity, however, diminished somewhat during the dry period from 1909 to 1914. In some cases when the trees died the discouraged farmers planted no more. The amount of work involved was also an obstacle. The trees required special care and many of the farmers felt that the area protected was too small to justify the effort. Some pointed out that the windbreak proved satisfactory for the small orchard and garden, but that it was too big an undertaking to provide adequate shelter for the cropland in general.

According to Phillips,[10] recent work of the Forest Service in western Oklahoma shows that in a year as dry as 1936 about 65 percent of the tree plantings were successful and that properly constructed windbreaks afford adequate protection to cropland even when they occupy only from 5 to 7 percent of the land.

MECHANICAL CONTROLS

Once the land was broken and the humus content of the soil largely destroyed, the raising of corn, cotton, wheat, and other crops often proved impossible. Cash crops were an economic necessity. Consequently it was important to develop some method by which crops could be produced with a minimum of erosion hazard. Dry farming was developed as a method of producing crops in regions where rainfall was deficient. The frequent stirring of the soil left it susceptible to erosion by wind and water (fig. 5). Gradually the techniques were modified so as to reduce this hazard and in the end soil-conserving methods of cultivation emerged.

THE CAMPBELL SYSTEM OF DRY FARMING

Dry farming was new only in name. It had been practiced for centuries in various parts of the world. In the United States it had been used as early as 1849 by isolated groups of western pioneers. After the drought of the early 1890's, when the general public had accepted the idea that the Great Plains were unsuited to permanent farming, the Campbell system of dry farming came into prominence and was hailed as the savior of agriculture of the Plains. Campbell's system, it was claimed, not only rendered the soil more absorbent but also prevented the development of a loose blanket of soil, which was easily swept away by high winds. It was said that Campbell had proved that the drifting sands of the prairie could be made practically stationary, and that, though he did not assume the power

[10] George R. Phillips was formerly Oklahoma State forester. He is now with the Division of Private Forestry in the United States Forest Service.

to keep the wind from blowing, he had proved that he could so handle the soil that it would not drift and move.

Undoubtedly the system worked for a time in some parts of the semiarid West. The big mistake was in assuming that a single system was adapted to all the soils and climatic conditions on the Plains.

Campbell's main thesis was that if the ground were kept stirred at the proper time so as to produce a soil mulch the benefit of the rainfall could be carried over to the time when moisture was most needed. The soil was to act as a reservoir. The system required a subsurface packer, a wheeled tool which sank from 2 to 4 inches into the pulverized soil and pressed the soil underneath but left it loose on top. It was designed to leave the soil in a "small cloddy"

FIGURE 5.—As a result of frequent plowing, the wind has removed most of the topsoil from this field in Payne County.

condition that would hold the moisture without being susceptible to blowing. Other implements were used, including the corrugated roller, the disk, the lister, the acme harrow, the press drill, the turning plow, the float, and various plows and harrows. Flat rolling was frowned upon by the experiment station (*21*, *p. 3*) because at that station it did "not tend to conserve soil moisture or increase the crop yield. . . ." "Rolled soil," it was explained, "is blown by winds more readily and is not in condition to receive the rainfall to the best advantage."

The farmers of the plains soon came to realize that surface rollers and packers had no place in dry-land agriculture. The old type of roller and packer gave way to the corrugated roller and the subsurface packer.

. . . where the soil is likely to "blow" the roller, or the float, should seldom be used, for the reason that both have a tendency to pulverize the surface and leave

it at the mercy of the wind. For all purposes of clod crushing and packing, the subsurface packer of the Campbell type that firms the under portion while leaving the surface loose and rough is better. The coarse mulch left by the subsurface packer meets the requirements of the western plains better than the fine or "dust mulch" left by the roller or the float. The use of soil packers is largely a question of geography and soil physics. The roller and the float may work all right where there is abundant moisture and no high winds, but in the semi-arid west—look out (*26, p. 41*).

The subsurface packer consisted of a series of wedge-shaped wheels about 18 inches in diameter and set 6 inches apart. The object was to pack the lower part of the plowed soil but leave the surface loose. The subsurface packer soon became an indispensable tool for the progressive dry-land farmer. It was used in connection with the disk for spring plowing, and many farmers used it several times during the growing season.

The corrugated roller was also designed to apply the pressure toward the bottom of the furrow, where it was most needed. It left the surface ridged, and on land thus rolled there was less danger of the wind blowing away the soil and the seeds that had been planted. It was pointed out, however, that the corrugated roller, if followed by a harrow, which was also advocated by Campbell, might leave the soil in a blowy condition. Therefore the disk was considered superior.

Campbell started cultivation in the early spring with an ordinary disk run about 2 inches deep, the land having been broken or listed sometime before, preferably in the fall. In June or July he recommended plowing 6 to 7 inches deep, followed by a packer and later by a harrow. It should be emphasized that Campbell was careful to plow his ground when it was moist underneath, but would not disk if the soil tended to stick to the disks. He followed the same practice in cultivating, pulverizing the soil mass but leaving a moist mulch on top. It was stated that—

> the soil in Campbell's fields was moist enough to be squeezed into a ball, while identical soil fifty feet away, cultivated by ordinary methods, would blow away in dust when released (*69, p. 7891*).

The press drill was also advocated. It helped to induce earlier sprouting by pressing the earth around the seed and conserving the moisture. Because the seeds and young plants did not blow out of the ground, roots developed and enabled the plants to get a firmer hold upon the soil.

The Campbell system captured the imagination of the farmers. It was contended that bountiful crops could be grown on half the precipitation of the Great Plains, that the region could be made the most prosperous agricultural area in the world, and that crop yields could easily be doubled. Western Oklahoma farmers participated in the International Dry Farming Congress, organized local conferences, invited Campbell to address the farmers of the State, and the agricultural journals publicized his system so widely that practically all of the farmers were familiar with it. It was estimated, however, that in 1911 only 1 or 2 percent of the farmers practiced dry farming and that probably not over 10,000 acres in western Oklahoma were dry farmed.

Dry farming undoubtedly produced some favorable results, but it was eventually realized that corn, wheat, and cotton could not be raised profitably in all sections of Oklahoma. It was predicted that extremely dry years would come again and that they would again be accompanied by crop failures. The dry years of 1910–11 fulfilled

this prophecy. Certain of Campbell's methods continued to be used, but dry farming in its entirety gradually went out of practice. It was broken down into its component parts, each of which received individual attention and was considered in relation to the needs of specific climatic or soil types.

FALL AND WINTER PLOWING

One of the dry-farming practices that continued was deep fall and winter plowing. It provided a loose mass of soil that decreased runoff and, if stalks, trash, and green manures were turned under, added humus to the soil. Gradually it came to be recognized that deep plowing aggravated wind erosion and often proved more harmful than beneficial. Even more important than the maintenance of fertility was the retention of the soil itself, and it was repeatedly advised that sandy land should be excepted from winter plowing.

Many farmers abandoned deep fall and winter plowing when it was discovered to be detrimental to certain types of soil. The turning plow was discarded, and some farmers adopted the lister, others the disk or packer, while still others left the soil undisturbed. Some still insisted on fall turning, and it was asserted that subsequent disking would stop the soil drifting. Others claimed that deep plowing would not cause drifting if organic matter were worked into the land, or else they continued the old method of plowing deep and harrowing afterwards, saying that their sandy land would not blow. The experiment station (*61*) advised fall plowing and the use of the smoothing harrow to prevent blowing.

For some crops fall plowing was particularly desirable. Alfalfa, especially, needed a good seedbed prepared in the fall. It was observed that one farmer plowed in the fall, harrowed several times, and left a fine mealy surface. It was suggested that this would have been satisfactory if the land had been lightly disked, but a corrugated roller followed by a harrow was used, and the loose soil blew away (*20*). In planting winter wheat, it was also necessary to turn the land, but farmers were warned that the soil should not be made too powdery.

Practices and opinions regarding fall and winter plowing were varied partly because farmers had developed prejudices owing to their earlier experiences. Later it was found that fall plowing could be employed in some regions without disaster if practices were adapted to particular types of soil. This opinion is reflected in a statement by a Kiowa County farmer (*15*).

> I have been here now for seven years. The first five of those years I was kept from winter plowing by the old settlers. They said the soil would blow so if plowed. Now I plow to prevent blowing.

It was also impossible to generalize on the subject of fall plowing because of great variation in precipitation from year to year. For a winter which was relatively wet, deep plowing in the fall was satisfactory, but if the winter were dry, the winter and spring winds carried the soil away.

LISTING

The lister, which left the land in ridges, proved more effective than the turning plow for controlling wind erosion and it early became one of the most popular plows on the Plains. It was used especially

in preparation for spring planting. Many of the farmers merely listed the land once, shortly before planting, and planted the crop in the furrow. A farmer (*66*) with 8 years of experience in Stephens County explained his method of listing and claimed that it would prevent blowing.

> Take stalk cutter and cut stalks, take lister and take off wings or fix it so that it can't turn up any soil. Run lister between old rows as deep as team can pull letting soil fall back into the middle, leaving grass and stubble on old row to catch the sand. Plant corn in old middle and work out gradually, leaving the old grass until corn is knee high. Then work out old row and you have beat the wind and have a fine mulch on your land. This is experience, not theory.

Often the crest of the ridge, being considered too high, was topped off with a section, A, or other type of harrow. Others listed several weeks before planting, then relisted to break down the middles of the ridges. Bishop (*19*) held that this method of land preparation would, to a great extent, prevent blowing and was superior to cross listing.[11]

> None of the advanced methods of tillage can be practiced on the lighter sandy lands. Even fall listing is out of the question unless you know your soil well enough to know that it will not drift, if a dry and windy spring happens to follow. In the spring of 1901, I saw many lister furrows completely filled with the drifting sand. This was again repeated in the spring of 1904 on early spring listing and the same was true again in the spring of 1911. I learned my lesson in the spring of 1901 and did not get caught on the other two dry and windy springs. I am inclined to think that it pays to list and relist before planting sandy land. I mean by that to list and then plant when you "bust" out the second time. Certainly that is about the limit of tillage for a sandy farm which has been known to fill the lister furrows even after planting time.

It was essential to list crosswise of the prevailing winds, though not necessarily exactly at right angles to them. If the land sloped, erosion by rain and wind both had to be considered. The ridges, thrown up as miniature windbreaks, were not dragged down until the crop had grown sufficiently to afford protection to the soil. Occasionally they were not harrowed at all, or were harrowed once or twice (sometimes cross warp), and gradually worked down as the crop was cultivated. In the fall the land was frequently left in ridges without any harrowing during the winter.

Generally, shallow listing was advised, especially in planting. According to Wright (*79, p. 10*) of the Oklahoma Agricultural Experiment Station, deep listing was not advisable. Some listed as many as three times before planting. In one instance the land was listed early in the spring, and about May 1 the ridges were relisted. Others recommended a lister with planting attachment, using press wheels. A homemade harrow, consisting of a 1-inch board 2 feet wide by 3 feet long, having eightpenny nails driven through it, was used to scratch the soil. This was tied on to the lister, placed longways with the furrow, and slanted downward. Sometimes corn, other stalk crops, or even alfalfa, was planted in the lister furrow to protect it from the blowing sand.

Land was also listed in the summer as a protection against drought and soil blowing. In some cases, the wheat stubble was listed, then

[11] The ground was listed in one direction one time, and the next time in the opposite direction.

later the ridges were split with a 20-inch sweep after the lister share and moldboard had been taken off.

The lister, disk plows, and harrows were used to some extent in the winter to roughen the soil, but on real drift soil winter listing was a failure.

Many farmers found listing the best of the many techniques that they put in practice. Although it occasionally failed to hold the soil, it probably was the best method of plowing used in the first decade of the century, as well as the one most widely practiced.

DISKING

Another very popular tool was the disk harrow. It was the most important tillage tool for grain farming and it was conceded by many that it was the best tool for conserving moisture more satisfactorily if used on stubble, after harvest, and before plowing time. Early in the history of dry farming the disk harrow was used to increase the moisture-holding capacity of the soil. When blowing developed, the disk harrow was employed to prevent drifting. Almost every farmer had a disk of some kind and used it extensively. When dry farming became popular, it was used in place of the packer to settle or pack the soil, since few farmers had packers. Next to the lister, it was probably the most widely used and effective implement for controlling blowing.

In the winter or spring farmers used the disk harrow on the old dead stalks and grass when the soil became loosened by the winds. It would press the trash into the soil and, when run east and west with the disks set nearly straight, would roughen the soil and check blowing. This was true when the soil was only moderately sandy, but if it were real blow sand and had been turned in the fall, nothing would hold it.

On extremely blowy soil the disk entirely replaced the lister or the turning plow. It was often disastrous to list or break land early in the season, when it was safe to prepare the ground for planting only by disking. Frequently the disk was used after listing or breaking. Since few farmers had subsoil packers, the disk was frequently used as a substitute. This conserved the moisture, roughened the surface, and reduced blowing. It also settled or packed the soil, the disk taking the place of the subsurface packers and helping to bring about the desired cloddy, but not dusty, mulch.

Various kinds of planters, such as the two-row planter with disk attachments, which made furrows like a lister, were used. Even the disk feed drill, with the feed closed, was used as a plow to prevent blowing.

In preparing land for planting it was unsafe to use the ordinary harrows to make the surface smooth. Here the disk harrow was used to level the surface somewhat, but not enough to start blowing. Sometimes on sod that had become depleted and spotty alfalfa and Bermuda grass were worked into the surface by disking.

As used in erosion control, the disk was not always effective, but it was the best tool the farmer had for certain stages of land preparation and in many instances served temporarily to check blowing on moderately loose, sandy land. The old methods of land preparation on sandy soils gave way somewhat to disking, because after ordinary breaking the farmer had frequently seen his seed and young plants blown out of the ground not once but several times in a season.

OTHER TYPES OF PLOWING

Nearly all those interested in stopping wind erosion used some method of roughening the soil. Plows of almost every variety were used. Sometimes ordinary cultivators were used to prevent blowing, particularly in cultivating crops.

> I plowed seven acres of ground about eight inches deep in April. This ground got a good rain before planting. May the first I top-planted corn with two row planter. Before corn came up the wind drifted sand from an adjoining wheat field over the strip of corn which caused it to blow and gave it a mulch of blow sand over the entire patch.
>
> On May 17, after a shower of rain, I cultivated every other row to check blowing and May 31 the rows which were skipped were cultivated again after a shower to check blowing (*63*).

The five-tooth cultivator was used, and sometimes every alternate row was planted. Both procedures tended to check the blowing. Farmers used almost any kind of plow in cultivating and worked out their own methods to stop blowing. One farmer (*73*), who used oats as a nurse crop for alfalfa, first prepared the ground thoroughly and then with a 10-inch shovel laid off furrows at right angles to each other across the field. He found that this stopped the soil from blowing until the oats got big enough to protect the alfalfa.

All the plows on the farm were used, and farmers used their ingenuity in devising new types.

> I can't get the blacksmiths to exactly understand me. I have been trying to study out a plan that I could run under the dead grass stubble and kill out the early weeds, then use a shovel instead of a lister for the planting; or likely a better way would be to run two sweeps on a cultivator and follow with a two-row rod planter . . . (*75, p. 7*).

Even the harrow, so disastrous in some instances, proved beneficial in others. In one case the smoothing harrow was recommended by the experiment station (*61*) to pulverize the soil and prevent blowing, but it was stated that the soil had to be in exactly the right condition to be harrowed. The suggestion was also made that the harrow should not be used until the little lumps of soil were slightly baked.

The plowing techniques reduced the rate of erosion, but as time went on they proved less effective because of the progressive deterioration of the soil. Their chief weakness was that they did not increase the organic content of the soil or keep it from declining.

WATER EROSION

CAUSE AND EXTENT

Like other sections of the West, western Oklahoma experiences an irregular recurrence of droughts and periods with heavier than average rainfall. During the droughts, dust storms and drifting are a frequent occurrence. In periods of heavier rainfall water erosion assumes greater than normal importance. Both types of erosion may be directly attributed to misuse of the land—to the breaking of the sod, the cultivation of crops, and burning off the land.

A large part of the total rainfall of the State, which varies from an average of 45 inches in the east to 18 inches in the west, is concentrated in the spring and early summer months, often as much as one-fourth of the year's total falling in a single month, sometimes

in a single storm. Floods occur frequently, and river channels shift back and forth across their sandy flood plains.

The devastating effect of floods is well described in the Oklahoma Farmer (*6*).

A fair idea of the enormous losses caused by the flood in the South Canadian river two weeks ago Oct. 1904 can be gained by travelling some distance along its course in Oklahoma . . . In the Bridgeport country the river rose in one leap from a feeble stream, winding its way in a bed less than a quarter of a mile in width, and became a vast flood that rolled a wall of water ten feet high, and in most places spread to the hills on both sides of the river. Farmers declare that the roar could be heard five miles. Above Bridgeport the river was two miles wide . . . One farmer near here owned a well-improved valley farm . . . On the day before the flood the farm was green and fertile . . .

The water came in the night and next morning the river had deposited from six inches to four feet of sand over the entire farm. All the improvements were washed away and the residence sunk in the sand half way to the eaves.

FIGURE 6.—Floods frequently destroy growing crops and leave behind them thick deposits of sterile silt.

Today the farm is a barren waste of white sand that will not produce the most worthless weed, and through a portion of it runs a new channel formed by the river half a mile from its old bed . . . This condition prevails mile after mile along the South Canadian in Oklahoma. Many of the farmers were left almost destitute . . .

The oldest pioneer in Oklahoma does not remember ever seeing so much water in the South Canadian. Its greatest height prior to the last flood was in 1877 . . . the North Canadian reached then its greatest known height. It lacked only a foot of running over the north bank at the Darlington Indian Agency.

Although floods were a frequent occurrence even before the settlement of Oklahoma Territory, there is no doubt that the later ones were more instrumental in carrying away soil and that the silting of fertile bottom lands increased (fig. 6). Such was the experience of a farmer of Caddo County (*67*) who stated that:

In the fall of 1904 the South Canadian river overflowed a part of my farm and left a whitish, sandy soil, ranging from four to eight inches deep. This

soil is tough and seems to hold the water and is hard to work and does not produce like it did before it was overflowed . . . The lister will barely touch the black soil . . .

Further damage to farm lands was caused by the shifting of the river channels. In 1906 one farmer (*8*) reported an instance of the freakish behavior of the South Canadian River: " . . . it cut a channel through the Hare farm, near Mannsville, ten feet deep, sixty yards wide and a quarter of a mile long."

While the valleys were suffering from the effects of floods, sheet wash and gullying were taking their toll on the uplands and menacing the entire farming area (fig. 7). In the early stage of settlement, land was plentiful. Farms inundated by floods could be abandoned, as could the hillsides ruined by gullies and sheet wash. But with the turn of the century warnings of an impending crisis began to appear. Farmers were cautioned that the sandy loam soils of Okla-

FIGURE 7.—While the valleys suffer from the effects of flood, sheet wash and gullying take their toll in the uplands.

homa Territory were subject to the erosive action of the water and that they would lose their fertility if not properly managed. An occasional effort was made to call the attention of the farmer to gullies. He was advised to remedy the fast-growing evil; to change the cropping system; to alter the method of plowing where the hillsides were being defaced by gullies.

Throughout western Oklahoma during the period from 1905 to 1908 precipitation was above normal. Since scant rainfall had been the chief factor limiting crop production, agriculture expanded rapidly, accompanied by an increasing erosion hazard. The rainy period reached its culmination in 1908 (fig. 8). In the eastern part of the area the precipitation for the entire year was nearly twice normal, and of this rainfall two-thirds fell during April, May, and June. The storm of May 22–24 alone contributed 20 percent of the total rainfall of the year, and a number of stations reported over 9 inches in a single day. For the first time in the history of western

Oklahoma, water erosion was sufficiently spectacular and widespread to attract the attention of farmers in general. Early conservationists deplored the situation and criticized severely the farmer whose shiftless practices were responsible for the destruction. Although the surface of his soil was gradually being destroyed by erosion, he neither planted shrubs, nor terraced his land to prevent it. "Heavy rains get the best of the soil and when the creditor comes for his share, he finds a washy farm with furrows deeper than any grave" (*50*).

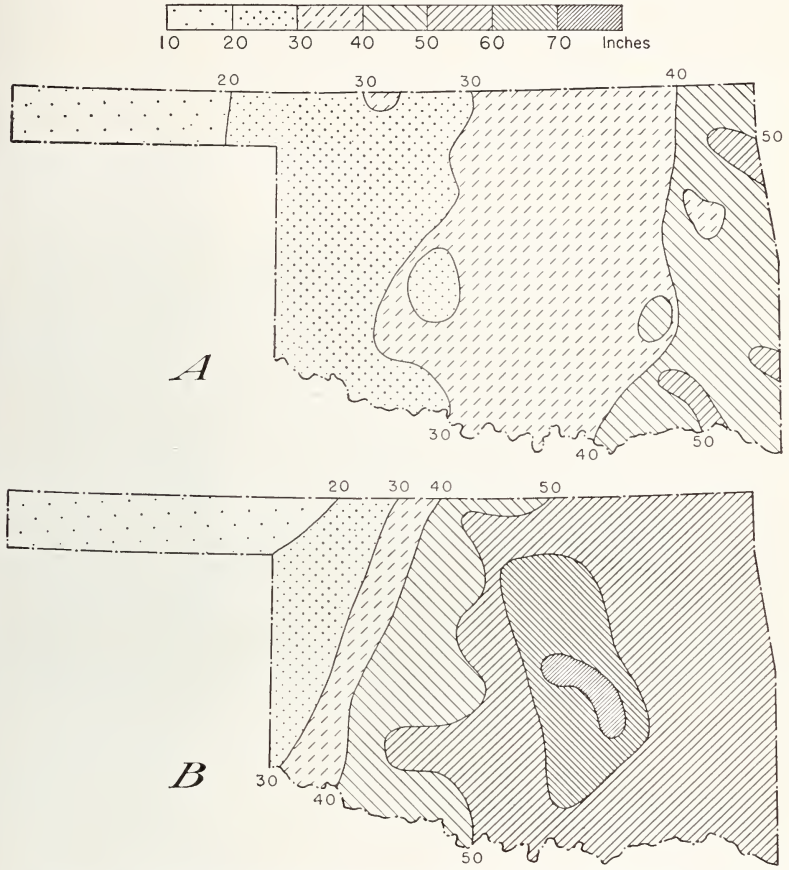

FIGURE 8.—Distribution of precipitation in Oklahoma: *A*, Average annual precipitation based on records for the period ended 1930; *B*, total precipitation for 1908.

It was a common experience to have a crop washed away, and commonly the farmer failed to profit by his experience.

As to soil washing, who of us has not annually experienced having twelve or more acres of our corn land swept down into the adjoining gulley by an all night dashing rain? Or our latest planting of alfalfa washed into the dead furrows and carried away to sprout and live a prodigal life on some overflow land? It seems that in our brief settlement of this state we have been aiding the elements in tearing up and destroying the land. In making our roads we plow deep furrows leading to the draws to aid in this annual soil waste. We plow our land and plant our corn with the lay of the land . . . Nor is this annual waste a merely local affair. It is general and the importance of it cannot be overlooked (*76*).

In 1908 the heaviest rainfall in the State occurred in the Blackjack region of central Oklahoma, and here the land suffered most from washing. The soil is predominately sandy and especially subject to erosion once the land has been cleared. Those sections which had been opened to settlement earliest suffered most severely. Farmers had been producing corn and cotton year after year, little livestock was raised, and it was customary to burn the grass and stubble each spring.

By 1908 the Blackjack farms were referred to as "a succession of gullies and bottom patches made useless by the sand washed over them from the hillsides . . ." (*9*). Fowler (*42*), a farmer from Oklahoma County, estimated that less than one-fourth of the land of the county was worth as much as it had been 6 years before. Should another flood like that of 1908 occur, he said, few farmers would be able to stay unless the soil were protected. According to Moorehouse (*60, p. 9*), agronomist at the Oklahoma Agricultural Experiment Station in 1910—

> in the more undulating sections of central Oklahoma, arable land has been so disfigured by the rush of water that no attempt is made to use parts of the farm once under tillage . . .

So critical did erosion become in the Blackjacks that it was suggested that the Oklahoma Farm Journal open a Blackjack department to give special attention to the serious problem that confronted the hill farmers.

Lincoln County, which was opened to settlement in 1891, had begun to feel the effects of erosion by 1904, and the comment was then made that upland soils were "fast moving to the seas" (*65*). In 1908 the rainfall amounted to 60 inches, and erosion was so serious that the Farmers' Cooperative Demonstration Work [12] of the United States Department of Agriculture decided to assign a man to work on the problem in Lincoln County (*13*).

The Blackjack section was the first large, contiguous area to be undermined by erosion. The same processes, however, were in operation throughout the western Oklahoma area but on a smaller scale. Gullying was spotty in its distribution, and in 1908 there were still large areas where water erosion was comparatively unimportant. In that year all sections of western Oklahoma, with the exception of the Panhandle, experienced abnormally high rainfall, although conditions were less extreme than in the Blackjacks. Complaints of poor farming methods and the consequent erosion began to pour in from all sections (fig. 9).

In Dewey County farmers (*52*) observed:

> The soil is deep and washes easily, and the roads are not the only places where erosion is going on rapidly. Some of the farmers will have to be mindful of their methods or in a few years their fertile corn land will have gone to enrich the ocean.

In Custer County farmers regretted that the washy hills had not been planted to Bermuda grass and a Washita County lawyer (*34*) wrote: "Considerable areas in this portion of Oklahoma have through the ruinous methods of farming become practically denuded of soil and worthless for farming purposes." Even in this area many of the sandy land farms were abandoned by 1911.

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[12] This has now become the Extension Service of the United States Department of Agriculture.

In the Deep Fork section the hillsides leading into the valley had been listed to corn, in most cases with the rows running up and down the slope. Great gullies had formed, making the fields in many places impossible to cultivate. The soil was washed down into the valley below, covering the crops there and clogging the stream. Under such conditions no amount of ditching or draining proved effective.

According to Fields, erosion was increased by the tenancy situation. Between Ardmore and Madill, in Carter County, most of the land was cultivated by tenants who seldom lived on a farm longer than was necessary to produce one crop and who, consequently, had no interest in the land itself. As a result worn-out, abandoned fields were to be seen on all sides. Most of them were so badly washed and gullied that it was almost impossible to believe that only a very few years

FIGURE 9.—Lister ridges running up and down the slope are responsible for both erosion and silting.

before they had been producing profitable crops. The farmhouses were empty, fences down, and out-buildings gone to ruin (*12*).

Farmers and conservationists complained of the serious results of erosion and attributed it to improvident husbandry. Seldom did they question the wisdom of breaking the Plains or the land policy that permitted it. For this reason the solution of the erosion problem was left to the individual farmer.

COVER CROPS

Cover crops aside from grasses were not used to any great extent to control water erosion. Frequently, however, farmers who used cowpeas, alfalfa, sweetclover, and other legumes as soil builders noted that they kept the soil from washing away.

Of these legumes sweetclover was probably the most widely used to stop water erosion. Some farmers complained, however, that stock would not eat it and for that reason they would not use it. After the

failure of Bermuda grass in western Oklahoma, sweetclover aroused much interest. Articles published in farm papers recommended it for stopping washing and gullying, and claimed that it would grow on land where nothing else could get a start.

Sweetclover does not seem to have been tried extensively in western Oklahoma. As late as 1914 there were doubts as to whether it would do well on light, loose, sandy soil in Beckham County, and ignorance was shown as to whether it was adaptable to other areas. Wherever it was tried it seems to have been successful and not only stopped washes but helped build up the soil.

BERMUDA GRASS

The campaign for the use of Bermuda grass to control water erosion began in 1902. Before this date it had been used to some extent as a lawngrass and for pasture. So successful had it proved that Fields, who was then connected with the experiment station, hailed it as the solution of the problem of washing soils. The rainfall from 1904 to 1908 was, in general, above average, and Bermuda grass flourished wherever planted. It grew in ditches, on hillsides, and on eroded land that would not support other types of vegetation. It spread rapidly and formed an ideal covering for sandy land.

As erosion became more critical Bermuda grass increased in popularity. It was used not only to check erosion but also for pasture. The hogs ate the roots, stirring up the ground and providing the necessary cultivation. As a hay crop it was less successful because it tended to become sod-bound if not cultivated occasionally.

During the period 1906–10 there was not a single issue of the Oklahoma Farm Journal in which Bermuda grass was not recommended (*54*). Fields noted with misgiving the deterioration of the land, especially in the Blackjack section, and pleaded with farmers to set their eroded hillsides in Bermuda grass. To those who argued that Bermuda grass would take their farms the reply was, "It would be a blessing to Oklahoma in many cases if Bermuda did take their farms . . ." (*47*). In many sections Fields' campaign for Bermuda met with success. Prizes were offered for the best patches, socially minded farmers gave away sacks of the roots, and his disciples all agreed that Bermuda grass was more valuable to Oklahoma than was bluegrass to Kentucky.

Farmers were ahead of the publicists. As early as 1902, the editor of the Oklahoma Farmer reported:

> I have just returned from a trip through central Oklahoma attending farmers' institutes and everywhere farmers who have tried Bermuda grass report good results . . . Now they are planning to put out large areas of it for pasture, especially in northern Oklahoma where much of the land has been broken out and summer pasture is very scarce (*31*).

By 1906 the use of Bermuda grass had spread to such an extent that the Oklahoma Farm Journal reported that there was scarcely a county in the Territory where hardy Bermuda grass was not growing well. By 1907 it had extended into the Panhandle, and after the unusually heavy rains of 1908 the Bermuda grass acreage increased rapidly, especially in the more arid sections. Fields (*32*), in 1908, noted that in Beckham County, farmers were beginning to appreciate the value of Bermuda grass and that in the sandy lands along the North Fork of the Red River the acreage was being increased as rapidly as possible.

In the Blackjack section, however, Bermuda grass was most enthusiastically received. It was here that Fields had first observed widespread deterioration, and for this section he recommended a complete change from crop production to livestock farming. In his opinion, Bermuda grass was the only means by which the Blackjacks could be saved from complete abandonment.

> The foundation of success must be grass and livestock. Grass comes first, for without it, these sandy, sloping soils will continue moving toward the sea. And grass for the blackjacks as for practically all the farms of Oklahoma, is bermuda grass. It will take hold of the washey hillsides, fill up the gullies and feed livestock through the driest of summers and well into the winter (*10*).

Mitchell (*58*) of Lincoln County was equally enthusiastic about the use of Bermuda grass and regarded it as the salvation of the hill farmers. He urged that the farmer "let it grow until it shall transform our depleted hillsides into pastures of carpeted green, and our farmers from a mortgage bondage into the full liberty of independent plentitude."

The planting of Bermuda grass in the Blackjack section was undoubtedly stimulated by the erosion crisis that accompanied the heavy rains of 1908. Farmers faced with the choice of complete ruin or a change of farm practices chose the latter. This was true in Lincoln and, to a lesser extent, in Logan, Oklahoma, and Pottawatomie Counties. In 1910 it was reported that more Bermuda grass was being planted in Lincoln County than in all previous years combined. The following year Mitchell (*59*) stated that—

> The assessors report for the last year was only 798 acres set to bermuda grass. This year's report shows 1,372 acres . . . We want to double our acreage every year until all of our rocky or washed hillsides are set to bermuda.

In spite of its popularity, Bermuda grass was not well received in all quarters. From time to time farmers objected because of its creeping tendencies, because, once sodded, it was difficult to rid the land of it. In wet years particularly did these objections obtain. If it was not plowed up in the winter, cultivation, instead of killing it, caused it to flourish. As time progressed and the advantages of Bermuda grass became more apparent, farmers lost their desire to dispose of it.

Because Bermuda grass was a perennial, it was difficult to incorporate it in any system of rotation. The extensive root system, so effective in holding the soil, took some time to develop. New roots were sent out from the creeping stems or runners, and gradually a compact mat developed.

There were many ways of planting Bermuda grass. Usually the roots were dropped several feet apart in furrows and then covered. Sometimes it was interplanted with cultivated crops. If planted between rows of corn, the Bermuda grass got a good start while the corn was small and remained alive while it was maturing, but did not grow much because of the shade. When the corn was cut, the Bermuda grass again grew rapidly and formed a good sod by fall. It was felt that this method would lessen the danger of winter-killing. The sod might also be set in the row and cultivated with the other crop, or the seed sowed before the crop was plowed and cultivation continued in the usual manner. By the next year the grass had become sodded and was used for pasture exclusively. The latter method of starting Bermuda grass, however, did not as a rule prove successful. The plants propagated from seed were not so hardy as those

that were sodded. They were more susceptible to cold and drought and took much longer to become established.

One farmer reported that he broke and harrowed his land for Bermuda grass and then drove across the field with a wagonload of roots, dropping plants a short distance apart in each wheel track and then stepping on them. Such methods of setting out Bermuda grass were too slow to be practical. Other farmers resorted to the manure spreader followed by a disk to cover the roots. If Bermuda grass roots were dropped by hand, they were covered with a cultivator; if interplanted with a crop, they were covered during the last cultivation.

Planting in ditches and gullies differed somewhat from field planting. A shallow trench was dug in the bottom of the ditch and a solid piece of sod tamped into the trench. It was predicted that if Bermuda grass were planted this way every 4 or 5 feet it would fill up gullies in 2 years. Mitchell (*56*) became eloquent on the subject of Bermuda grass for gully control.

> Bermuda is king; the uncrowned king of Oklahoma. . . . When our uplands are worn out so they will not raise cotton or corn; when there are so many gullies and gulches that we can no longer drive machinery across our fields, we set it to hardy bermuda . . . Every rocky spot, every washy hillside should be set to bermuda.

A farmer in the Blackjacks planted Bermuda grass in some of the gullies on his farm. By the following spring they were beginning to fill up, and he proceeded to treat the remaining gullies in the same manner.

> The humble Bermuda grass, patiently and persistently creeping over the surface, reaches down into these gullies, traps a little of the moving earth and holds it in place. Climbing on top of this it repeats the process, without the aid of man or helped a little by him, until the gully is completely filled (*3*).

Bermuda grass was especially successful on overflow lands, where it grew even more rapidly than on the thin soil of the hillsides and formed a closer mat. It was not easily drowned out even on land subject to periodic floods, provided it was not shaded. One farmer with 20 acres of almost worthless overflow land planted it with Bermuda grass which he secured from the experiment station. Within 3 years he had a fine stand that supported 40 head of cattle where 2 cows could scarcely have survived before.

The steepest hillsides, once sodded to Bermuda grass, would not wash, but sometimes the roots were washed out before the creeping runners were securely fastened into the mobile soil.

> I added several acres to my planting last year. My ground being a little sloping the excessive rains of last year washed my plowed ground badly, taking off the loose soil and partially washing my bermuda out before it had time to root. As an experiment, on the first day of July, after our big flood the night of June 30th, I planted perhaps two acres in the prairie sod on a sloping piece of ground using a diamond plow, running it on the bar to make a furrow, and going around the hill so that the water running down the hill would run crosswise of the rows and not wash out the bermuda, but would have a tendency to wash the dirt into the furrow covering up the bermuda. We did not cover this planting as we did in the plowed ground, but used larger pieces of sod—as large as a man's hand or larger. Although it was dry for quite a spell, this sod planting grew fully as well as that on the plowed ground and I will plant ten or fifteen acres more this year on sloping ground on the same plan. We are having a wet spell and I have my men planting some of this sloping ground today and will continue to plant in the wet spells until all of this side hill ground is planted (*28*).

Bermuda grass was planted in the bottoms of washes, on the embankments of ponds, and on land worn out by long-continued cropping without fertilization. It was even suggested for creek bottoms that were badly cut up, since it could stand under water for weeks at a stretch and still thrive. Farmers also procured sets in order to provide the livestock of the farm with suitable pasture throughout the hot summer months. They were warned, however, against overpasturing the field the first summer.

To those progressive farmers who were trying to protect their soils against the destructive effects of flood and rain, Bermuda grass seemed a godsend. But Bermuda was a southern grass and remained so in spite of the fact that in some years it could be grown successfully in northern areas. The cold, dry years of 1909–10 checked the westward

FIGURE 10.—Gully and sheet wash in Lincoln County. The little pillars of soil have been held in place by the grass roots.

and northward spread of Bermuda and in large areas, where it seemed well established, it was completely killed out.

By 1914 it was evident that Bermuda grass was not adapted to much of western Oklahoma; that it was unable to withstand the recurrent droughts or abnormally cold winters. According to Fields (*41*):

> For ten years, conditions were such that bermuda grass gave fairly satisfactory returns over all of Oklahoma except the northwestern fifth. Then along came five dry years which practically put it out of business except in the eastern half of the state, and along the Red River a little farther west.

The end of the Bermuda era found the farmers still searching for a satisfactory cover crop—either new grasses or hardier species of Bermuda.

OTHER GRASSES

From time to time other grasses had been tried but proved unsatisfactory (fig. 10). The experiment station in 1894 had pointed out that tame grasses and drought did not go well together. The follow-

ing is from one of the bulletins (*55, p. 55*) of the station published in that year:

> The recent dry, warm weather has tried tame grasses enough to show that some are weaker than others. Some of the tender ones have been nearly killed. In the experimental plats of the Experiment Station grasses sown this year show a vast difference in their drought-resisting qualities. Among those which are reported to have done the best thus far are Bermuda grass, Orchard grass, Awnless brome grass, Perennial rye grass . . .

Bromegrass was tried but was not successful. Bluegrass, timothy, and clover were successful in the northeastern part of the State but were not much recommended for western Oklahoma. Bluegrass and orchard grass did fairly well on bottom lands farther south and west but were no good for the eroded, hilly section. Farmers in Custer County, however, seemed to find bluegrass a success, and some farmers preferred it to Bermuda grass. It was also tried to some extent in Lincoln County, and for timbered bottom land a mixture of bluegrass and orchard grass was recommended.

Johnson grass, the outlaw, was not popular nor recommended generally for washy land.

> I never knew it to grow in a pasture, but it will surely grow on good, cultivated land when started, and it is there to stay. It doesn't like washed out land a little bit, but it takes the best land and you can't keep it out (*14*).

But this attitude was not universal. A farmer in Canadian County felt that since the native pastures were growing less grass each year the Johnson-grass law should be repealed. He pointed out the drought-resistant qualities of the grass and said that if farmers were permitted to sow their land in Johnson grass, hundreds of thousands of acres of eroded land could be restored to profitable use.

When the coarser grasses were eliminated from the West by overgrazing they were replaced in some sections by curly or creeping mesquite. Like Bermuda grass, it spread rapidly by means of stolons, but it was hardier, being less susceptible to both drought and cold. After the Bermuda grass failure in the Northwest mesquite was generally recommended.

Other grasses that were tried might have produced more hay than Bermuda, but in sections where the climate was favorable none served as well in erosion control.

AGRONOMIC AND ENGINEERING PRACTICES

PLOWING

Although it was recognized that the planting of cover crops was comparatively successful for checking sheet wash and gullying, their use was limited. The economic system required the production of cash crops and the prime concern of the farmer was to secure adequate moisture. Methods of plowing were adapted to this end, and few realized the dangers of soil washing. Deep plowing was first recommended as a method of storing moisture. Farmers claimed that plowing from 7 to 9 inches deep would unlock the subsoil, create a reservoir that would hold the water, and increase the crop yield at least 50 percent.

Mitchell (*57*) of the Farmers' Cooperative Demonstration Work of the United States Department of Agriculture advised farmers to plow a little deeper each year until a depth of 12 to 16 inches had been attained. Experiments with deep plowing, reported by the

editor of the Hobart News Republican (*7*), showed that crop yields increased with depth of plowing. The use of the turning plow instead of the disk was also recommended in the report.

Few references to deep plowing as a method of checking soil wash appeared before 1908. In the Blackjack section, where the soil was sandy and the subsoil relatively near the surface, the effects of shallow plowing were most conspicuous. As early as 1904, it was recognized by some farmers of Lincoln County that their lands were particularly subject to soil washing and that the need for deep plowing was urgent (*65*). An occasional article expressed regret that farmers neglected deep plowing; that most farmers plowed only deep enough to supply the next rain with a good mouthful of earth to carry away. Everywhere that shallow plowing was practiced the best soil was being removed and the yields were becoming smaller.

After the heavy rains of 1908, such references became common for all sections. Knapp (*51*), the noted southern agriculturist, considered that deep plowing would obviate the need for terracing. After heavy rains the water would be retained in the furrows until it could be absorbed by the subsoil.

It was further suggested that the deeper the land was plowed, the less was the danger that young plants would be drowned out during continuously wet weather. Root development would be encouraged, which would, in turn, check washing. Burlison (*23, p. 15*), of the Agricultural and Mechanical College, stated that Oklahoma had lost more plant food by surface washing in 1908 and 1909 than had been removed from the soil by crops during the same period. If humus was lacking, deep plowing was also recommended to aerate the soil. If trash was turned under in plowing, it helped to retain the moisture and to prevent washing.

As a rule, however, farmers continued their shallow plowing. If the principles propounded in agricultural journals did not exactly fit conditions on individual farms, the farmers were inclined to scoff at "book farming" instead of adapting the principles to meet their needs.

Closely associated with deep plowing were fall and winter plowing. The advantages of these were summed up by English (*30*), of the Farmers' Cooperative Demonstration Work:

> It saves the soil . . . It adds plant food to the soil . . . It enables the farmer to plow deeper . . . It increases the water holding power of the soil . . . It enables the farmer to plant winter cover crops . . . It enables vegetable matter which has been plowed under to decay . . . It enables the soil to absorb rain rapidly, thereby lessening soil damage by washing.

With the exception of planting Bermuda grass, no other method of soil conservation received as much publicity as did fall and winter plowing. Fields was among its advocates, as was also the experiment station (*61, p. 24*). They recommended that the soil should be plowed during the fall and winter months or very early in the spring, since a broken surface would absorb more rain than a smooth, hard soil. Furthermore, any snow that fell throughout the winter would be retained in the plow furrows. It was contended in some quarters that fall plowing, especially on sandy land, increased washing unless accompanied by a cover crop. As a remedy it was suggested that the plow should be made to ride squarely on the bottom, that the land side should not cut deeper than the share side, and that the land should be turned completely over and not left standing on its side. This would avoid a succession of little channels in the field, into

which surplus rain would settle, begin to trickle, and soon wash into ditches.

Farmers were cautioned against always plowing around fields. This would result in the digging of a deep dead furrow in the center of the field and the piling up of earth along the fence lines. The dead furrow caught and held the water. If the dead furrow followed the slope of the land the gullying hazard was greatly increased. One method of avoiding this was described by an Oklahoma County farmer (*68*):

> We do it this way (nearly all our fields are one-half mile through), we lay it off in large lands and back furrow until we get from ten to twelve acres plowed. Then we lay off another land with back furrow about fifteen rods from first one, and back furrow as before until we have about ten acres between lands. Then we turn the other way and plow out the center, driving team to fence as close as possible all the time; do not plow ends out till field is finished. In replowing we put our back furrows where our dead furrows are the previous plowing, thus keeping our field level . . .
>
> Plow deep as you can pull your plow with decency. If your plow comes out and makes a skip, turn around and catch it. Don't leave one hole.

For poorly drained land, it was suggested that dead furrows might supply the necessary drainage. In breaking the ground the lands were laid off 1, 2, 3, or 4 rods wide, according to the number of drains needed. During dry seasons the dead furrows were dammed up at intervals to hold the water and during rainy seasons the furrow could be plowed as much deeper as seemed necessary.

Soil was also washed away if furrows were dug on either side of the drill before planting. The furrows would fill with water, and the seeds or young plants were carried away.

For land preparation, some farmers used the lister exclusively in place of flat breaking. It was particularly useful if the land was either poorly drained or very dry. On wet land the rows could be drilled on the ridges after they had been partially dragged down; and on dry land, stalk crops, such as corn or kafir, could be planted in the furrow.

Bishop, a contributor to the Oklahoma Farm Journal and an authority on erosion control, recommended that lister furrows on regular slopes be run at an angle with the incline so as to hold the water but permit some drainage out of the lister furrow before the water broke through the ridges. The plan called for careful judging of levels, but it was claimed that some farmers had used it successfully to prevent washing.

The lister was used in the fall in place of the turning plow and the land was then relisted in the spring, both to make a good seedbed and to prevent washing. When the land was relisted the ridges were split and then harrowed down. One objection to listing was the occurrence of washing in the furrow and the puddling of water, which might drown the plants. This was forestalled to some extent by filling the furrow so that the soil would not wash over and cover up the plants.

No method of plowing to check erosion was completely satisfactory. In dry years the soil blew away; in wet years it was washed off. Efforts to control one of the evils frequently accelerated the other. Plowing could not completely overcome the effects of a climate that varied from drought to extreme rainfall. But had the farmers plowed their land judiciously there is no doubt that water and wind erosion could have been checked to a large extent.

TERRACING

Before 1914 there was little terracing in Oklahoma. Some of the farmers were familiar with the practice in the East, but as late as 1911 others knew of it only by name.

> Terrace your rolling lands. "What is terracing?" "What do you mean?" I hear some one say. You from the South Atlantic States know. You have seen fifty to sixty inches of rainfall per season taken care of without the loss of a shovelful of soil to the square mile, but as to the fellow from other locations who does not know, I will say you will have to get your information from U. S. Bulletins as our Experiment Station does not teach the subject and our farm journals are not featuring the system. Yet this continual loss by washing is the most serious problem now facing the farmer and his future source of income.
>
> And it can all be avoided at an expense of not to exceed twenty-five cents per acre of your own time. I sincerely trust that you will secure the best literature published on this subject and thoroughly acquaint yourselves with the wonderful possibilities of terracing, thereby saving your soil . . . All will agree

FIGURE 11.—An unchecked gully in the Blackjacks.

that water is the farmer's very best friend when rightly controlled but his very worst enemy when turned down hill in a loose cotton row (*25, p. 11*).

Among the early advocates of terracing was Crawford, of Greer County. He (*27, v. 14, no. 14*) encouraged farmers to terrace and ditch their washy soils rather than abandon their land. Others advised the farmers to consider the practices employed in the East and profit by their experience if they would hand down to posterity farms of increased productiveness instead of barren waste.

By 1914 the advantages of terracing were beginning to receive recognition. Broad terraces were described in considerable detail by Benton (*17*), of the Agricultural and Mechanical College, and the experiment station offered to supply specific information adapted to individual farms.

GULLY CONTROL

Singularly little effort seems to have been made to stop gullies (fig. 11). Dam building, terracing, and gully filling were not prac-

ticed to any great extent. Farmers were advised to fill up their gullies with straw and trash and then cover them with dirt. Cornstalks were also recommended, the stalks being placed in the gully longways with the butts pointing downhill. Other more indirect methods of stopping hillside gullies, such as crop rotations and plowing and planting grass, were advocated.

The farm eroded by water presented some complicated problems since the various parts of the farm had to be treated differently. A farmer who visited a run-down farm in the Blackjacks in 1908 recommended that 10 acres of badly gullied land be withdrawn from cultivation; other parts of the farm were to be ditched and drained and put in alfalfa; the old eroded orchard land on the hillside was to be abandoned and a new orchard started on level ground (*11*).

PONDS

Like other methods of controlling water erosion, the building of farm ponds was first recommended as a method of conserving water. During droughts both crops and livestock suffered; during rainy periods the water ran off the land rapidly. To store this water, ponds were built in draws and other low places. At a meeting of the Comanche County Farmers' Institute in 1903 the problem of the farm water supply was discussed. At that time Fields stated that the chief source of stock water in the future would have to be the ponds. Trosper (*4*) urged that ponds be built in every draw in the county, stating that these would be the "redemption of the great southwest prairie country." Enthusiam ran so high that the State Legislature decided that "any person or persons . . . who shall construct . . . a dam across a ravine or waterway, thereby creating a pond or reservoir of water . . . shall be entitled to a reduction of taxes . . ." (*64 pp. 195–196*).

Later, farmers were advised through the farm journals to build ponds to check wash. Upland farmers in particular were exhorted to build ponds, not for flood protection but to prevent heavy rains from washing the good soil into the bottoms. It was also pointed out that water stored in ponds above would also prevent washing in the lowlands, and in addition might provide some water for irrigation.

The editors of farm journals encouraged farmers to build ponds to check washing, and the experiment station suggested that they write for bulletins on how to construct ponds properly located to prevent washing. For the prevention of floods, ditches for the drainage of overflow lands and embankments along rivers and creeks were recommended. The embankments were to be planted in Bermuda grass. If dams in ravines or draws served as the walls of ponds, there was danger that the force of the water might tear out the dam and let loose the stored water. It was customary therefore to build ponds on a nearly flat area or on a gentle slope, and in consequence, washing on steep hillsides continued unabated.

SUMMARY

Because Oklahoma Territory was reserved for Plains Indians, its settlement was delayed until the best land in the adjacent States had been taken up by homesteaders. Other sections of our country

had been settled slowly and their farming problems emerged gradually. In Oklahoma Territory, most of the land in each of the Indian reservations was claimed immediately upon its being opened. In consequence, there was no opportunity for a normal development of systems of farming adapted to local environmental differences. Two major problems faced all incoming farmers—that of producing cash crops and that of securing adequate moisture for their production. The basic problem of adapting farm practices to the local climatic, soil, and slope conditions was subordinated to the immediate needs. The sod which held the prairie soil was destroyed; grain production, though not climatically suited to the Territory, spread throughout western Oklahoma; and the trees in the Blackjack section were felled, leaving the sandy slopes exposed to the wind and rain. The result was failure among farmers, an increase in tenancy, and one of the most rapid developments of an erosion crisis that the world has ever experienced.

In a recent publication Hall (*46*) has shown us that in Virginia, the oldest agricultural section of the country, erosion was recognized as soon as farmers began to cultivate the land. At the time when Virginia was settled there was a seemingly inexhaustible supply of land, and, as fields were eroded or worn out, they were abandoned and new lands cleared. In this way some natural recovery was made possible. With the settlement of Oklahoma Territory the last good farm land was appropriated and therefore its continued cultivation was an economic necessity. While sheet wash and gullying were the most serious forms of erosion in Virginia, the problem in Oklahoma was further complicated by wind erosion.

As soon as cultivation began, the more progressive farmers throughout the Territory realized the dangers of erosion and endeavored to control it locally. They discussed their problems with each other and through the columns of the farm journals. These writings form the best available source of information on erosion and its control in Oklahoma Territory. Many controls worked locally but failed when put into general application; others successfully checked erosion during rainy years but increased the danger of wind erosion during droughts, and methods for conserving moisture frequently left the soil exposed to damage by both wind and water. The one method of control that proved universally effective—a return to grass—seemed economically impractical.

Cover crops were in general the closest practical approach to natural sod. Of these Bermuda grass was by far the most popular and proved highly successful during the rainy period from 1904 to 1908. During the subsequent drought it was killed out over much of western Oklahoma. Johnson grass, Colorado grass, and crabgrass were tried with indifferent success. Alfalfa, which not only produced several crops of excellent hay during the year but also helped enrich the soil, was difficult to establish. Seed sowed in the fall frequently blew away and when sowed in the spring tended to wash out. The blowing sand frequently cut down the young plants. Cowpeas, another soil builder, also helped to check erosion; but if the vines were gathered for hay, the ground was left exposed. Stubble cut high and manure or trash of any sort pressed into the soil were highly recommended, but the majority of the farmers continued their old practice of burning off the fields at the end of the season.

Of greater interest to the average farmer was the development of methods of cultivation that would reduce erosion to a minimum and so permit the continued cultivation of cash crops. For this reason the Campbell system of dry farming was particularly popular. It was originally introduced as a method of conserving moisture, and it was believed that by making the ground more absorbent both run-off and water erosion were reduced. Its enthusiastic supporters claimed that leaving the soil in a small cloddy condition also checked wind erosion. For a few years the system as a whole worked fairly satisfactorily, except on very sandy soil. Then came one of the recurrent droughts characteristic of the semiarid West, and dust storms and drifting were far worse than they had been before the introduction of dry farming.

Although dry farming in its entirety lost in popularity, it had served to break down the traditional farm practices inherited from the more humid East. The recognition of its failure was accompanied by further search for mechanical methods for controlling erosion. Experience has shown that differences in soil, slope, or amount of precipitation were the factors that ultimately determined the success or failure of the controls attempted and that techniques that effectively checked erosion one year might cause serious damage the next year if climatic conditions were different. Fall and winter plowing were highly recommended by some, but on sandy soil it was found that the use of the disk alone was the most effective means of reducing blowing. Deep plowing to conserve moisture might merely increase the amount of loose soil subject to blowing during droughts. It was thought that the building of ponds would reduce erosion as well as conserve moisture, but if dams were built across ravines there was danger that heavy rains might tear them out and so cause accelerated erosion. Consequently most of the ponds were built on gently sloping lands.

The same local differences encountered by the early farmers of Oklahoma still persist and must be considered by those who are attempting to check erosion. A workable plan of land utilization requires a regionalization of erosion hazards based upon a thorough understanding of the climatic, soil, and slope conditions, checked against the past experience of practical farmers. Such a program was attempted by the farmers themselves with the expert advice of the editors of farm journals. It failed because it received the support of only a relatively small number of the farmers. Progressive farmers were at first able to check erosion on their own lands but erosion has grown to such an extent that today all of the farms are involved. Even the most carefully protected field may suffer because the adjacent land has been neglected. Although erosion has reached an advanced stage, a well-coordinated attack in which the land as a whole, rather than individual farms, is considered should succeed even though the attempts of a small group of scattered farmers failed.

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U. S. GOVERNMENT PRINTING OFFICE: 1938

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